NISTIR 89-4112

THE DEVELOPMENT AND USE OF A TRIBOLOGY RESEARCH-IN-PROGRESS DATABASE

S. Jahanmir and
M. B. Peterson

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National Institute of Standards
and Technology
Tribology Group
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Abstract

Preliminary efforts leading to the development of a research-in-progress database on tribology are described. The database contains brief abstracts of current tribology research being conducted by industry, universities, research institutes and government laboratories based on a survey of active researchers. It also contains information on the types of activities, general areas of interest, program objectives, and tribology applications. The database can be used to evaluate the current status of research and development activities in the United States. The survey results suggest that there is a strong interest in an applied research in tribology, and that the level of basic fundamental research is extremely limited. The primary program objectives cited in connection with the tribology activities include long life, low maintenance, failure-free machinery, fundamental understanding, and materials development for improved performance. It is planned to expand and update the database on a regular basis.

Introduction

Tribology encompasses cross-disciplinary research and practice in materials, lubricants, and component and system design. As a result, tribology research findings are published in a wide variety of specialized journals. This fact coupled with the diversity of tribology data makes it difficult for researchers and engineers who work in different fields to locate all pertinent information. As a result, advances in tribology have only slowly been incorporated into engineering practice.

One approach to reducing this problem would be centralization of tribological information in a computerized system that would be readily available. Widespread interest in this type of approach led a number of interested persons and organizations to discuss the issues in a series of technical workshops held at the National Institute of Standards and Technology (formerly National Bureau of Standards) that began in 1985 [1,2]. An outcome of those discussions was the planning and establishment of a computerized tribology information system (ACTIS) [3-5]. The system will acquire and make available a variety of databases: validated numeric data, design calculations, bibliographic information, research-in-progress, available products and services, and electronic mail information. Figure 1 shows schematically the six database components that comprise the total ACTIS system. These database components are described in Appendix 1.

The purpose of this paper is to describe the efforts carried out in the development of a research-in-progress database. A survey form was sent to 7000 individuals who have expressed an interest in tribology by joining a technical society or attending a meeting on the subject. The information

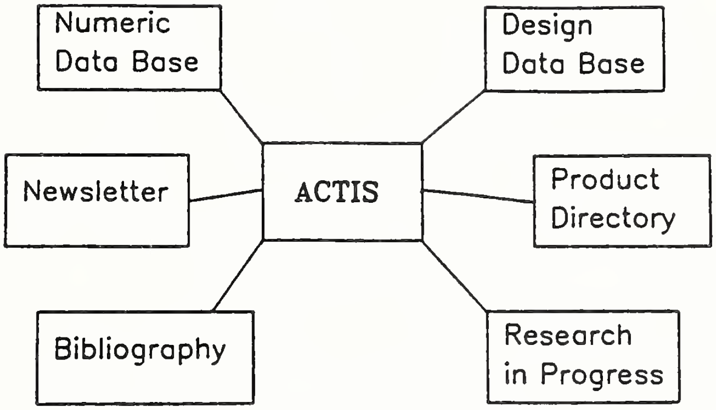

Figure 1. Structure of ACTIS, indicating the database components.

was compiled using a commercially available database management system and the results were analyzed. This information will be added at a later date to the ACTIS system as research-in-progress database. When completed it will contain a comprehensive set of abstracts of current tribology research being conducted by industry, universities, research institutes and government laboratories.

Development of the Database

A sample form used in the survey* is included as Appendix 2. An attempt was made to seed as much information about different areas of tribology as possible. The respondents were asked to supply their name, address, affiliation and telephone number for identification. Since many people who are involved in tribology do not consider themselves tribologists or do tribology research just as a short assignment, the respondents were asked to identify their main area of activity, if different than tribology. Questions were asked on types of activities, general areas of interest, program objectives, applications and materials. The second page of the questionnaire requested detailed information on current research projects including one paragraph outlining research descriptions, project goals, methods of approach, summary of recent findings, test conditions and future directions.

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*This survey was conducted by the Tribology Program of the National Science Foundation.

The mailing list consisted of approximately 7000 individuals; this included: Society of Tribologists and Lubrication Engineers members, American Society of Mechanical Engineers members, and those who had indicated that tribology is their first or second technology choice in ASME, American Society for Testing and Materials Wear and Erosion Committee, American Society for Metals Wear Resistant Materials Group, and mailing lists consisting of attendees of recent tribology conferences.

The total response was 484. This may seem low; but considering that only a limited number of the 7000 are seriously involved in tribology research and development activities, the response is considered reasonable and representative and probably represents about one-third of the tribology research and development community. The total response included 304 in industry, 100 in university and 20 in government. The affiliation of 60 respondents was not given or was listed as "retired".

Fifty-five percent of the respondents indicated that tribology is their main activity. Manufacturing, materials development, product design, reliability, mechanical components and systems, petroleum products and chemicals were among the main activities of those that did not consider themselves tribologists.

The information received on the survey forms was computerized using an R-Base 5000 database management system. The database structure was formatted similar to the survey form, such that the data could be easily searched according to each survey question. Questions included:

- type of activities
- general area of interest
- program objective
- applications and materials
- research description
- process or phenomenon being studied
- variables considered
- lubrication condition.

This database structure allows searches according to a logic-based relationship among the questions. The search results can be sorted according to either of the question fields. In the following paragraphs some examples are given which show how this database can be used.

A. Examples of Searches Which can be Conducted

In order to illustrate the usefulness of this database several questions were formulated and were used as a basis for searching. Since the particular database management system used allows Boolean logic searches, i.e., according to combination of logic statements, one can search through the database with various combinations of questions. The following examples illustrate responses to certain questions:

1. "Who is interested in research and development on metal-matrix or polymer-matrix composites for bushings?"

Database search output identified twenty people interested in metal-matrix bushings and twenty people in polymer-matrix bushings. Analysis of the data reveals the area of interest, and also gives name, address and telephone number of the respondents.

2. "Who is involved in a research and development activity on solid-lubricated ceramic rolling element bearings for high temperature applications?"

A total of five projects were identified, all in industry. These projects deal with rolling contact bearing tests for critical applications, self-lubricating cage materials, silicon nitride ceramic materials, high temperature lubrication and rolling contact fatigue mechanisms.

3. "Is there any research and development activity on ceramic materials for brakes?"

Eighteen respondents were identified who are interested in applied research on this topic; several are interested or are involved in the development of ceramic brakes. However, the research description indicated that none were actually working on ceramic materials for brakes. Quite often it was found that the indicated interest was different than the actual research being conducted.

4. "What are the objectives of basic research projects on liquid lubricants?"

Thirty-three projects were identified covering many different areas in lubricants. These projects dealt with hydrodynamic and EHD lubrication, lubricant viscosity analysis, lubricant additives, lubrication of ceramics, oxidation and stability of lubricants, boundary lubrication, and materials processing lubricants.

5. "Is anyone studying noise in rolling contact bearings?"

Twenty-two respondents were identified as being interested, three were found to be involved in a research program on the topic.

6. "Are there any research programs which study the structure or composition of films formed during liquid lubrication?"

Nineteen projects were identified dealing with lubrication of ceramics, magnetic recording devices, diesel engine, spacecraft mechanisms, and antiwear additives.

B. Current Status of Tribology Activities

The database can be used to evaluate the status of tribology research and development activities. The conclusions that follow are based on our analysis of the survey responses. Although the total number of responses, i.e., 484, may be too small for accurate statistical analysis, the sample is large enough to make some observations on the trends in tribology research and development in the U.S. Figure 2 summarizes the response to the question dealing with the types of activities. In this and subsequent bar charts the total percent response is larger than 100. This is because most respondents circled more than one answer. Figure 2 shows that most respondents are involved in applied research. A review of the work being carried out under "basic research" indicates that much of this also should be called "applied" if a rigorous definition of the term is used. A majority of respondents indicated interest in friction and wear (Figure 3). Lubricants, boundary lubrication and fluid film lubrication are also receiving a substantial amount of attention. Other areas such as tribomaterials and coatings, failure analysis and diagnostics, manufacturing and materials processing, and physics and chemistry of surfaces were found to be of great interest.

On the question of program objectives (Figure 4), the majority of respondents answered: long life, low maintenance, failure free machinery, fundamental understanding and material development for improved performance. Cost effectiveness also seemed to be one of the driving forces for many activities in tribology.

Figure 5 summarizes the response on applications. Sliding contact was the primary answer followed by fluid film bearings, rolling element bearings and bushings. There is also much interest on seals, gears and engines. It is clear from Figure 5 that essentially every component and application that was listed on the questionnaire is being studied. Other applications that were not listed on the questionnaire comprised of 20 percent of the response; these included: rotating machinery, metal forming

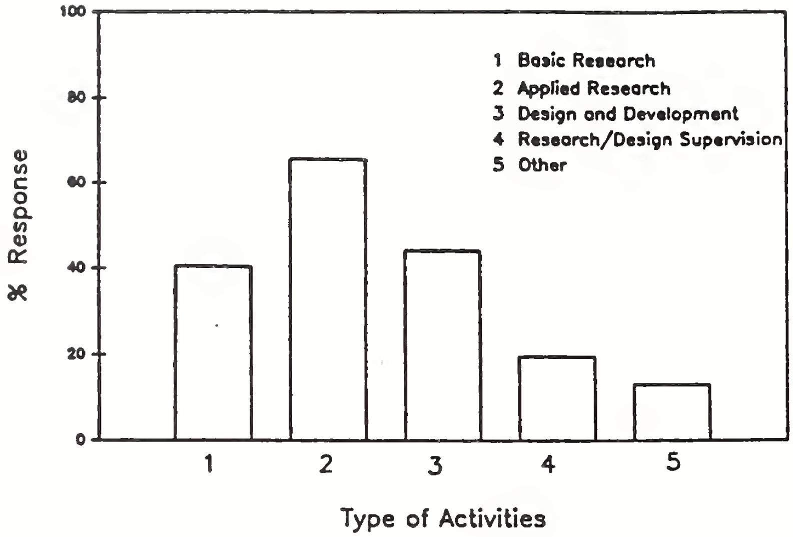
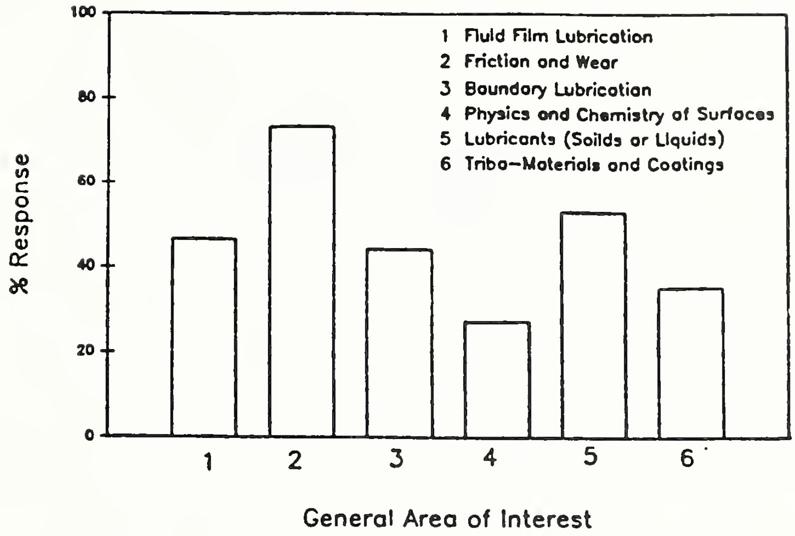


Figure 2. Response to type of activities; majority of respondents are involved in applied research.



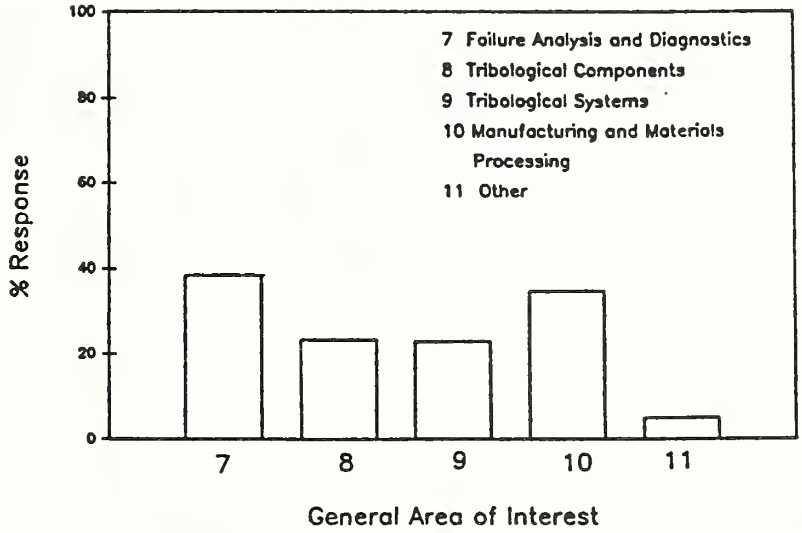


Figure 3. General area of interest of respondents; primary interest consists of friction and wear, lubricants, fluid film and boundary lubrication.

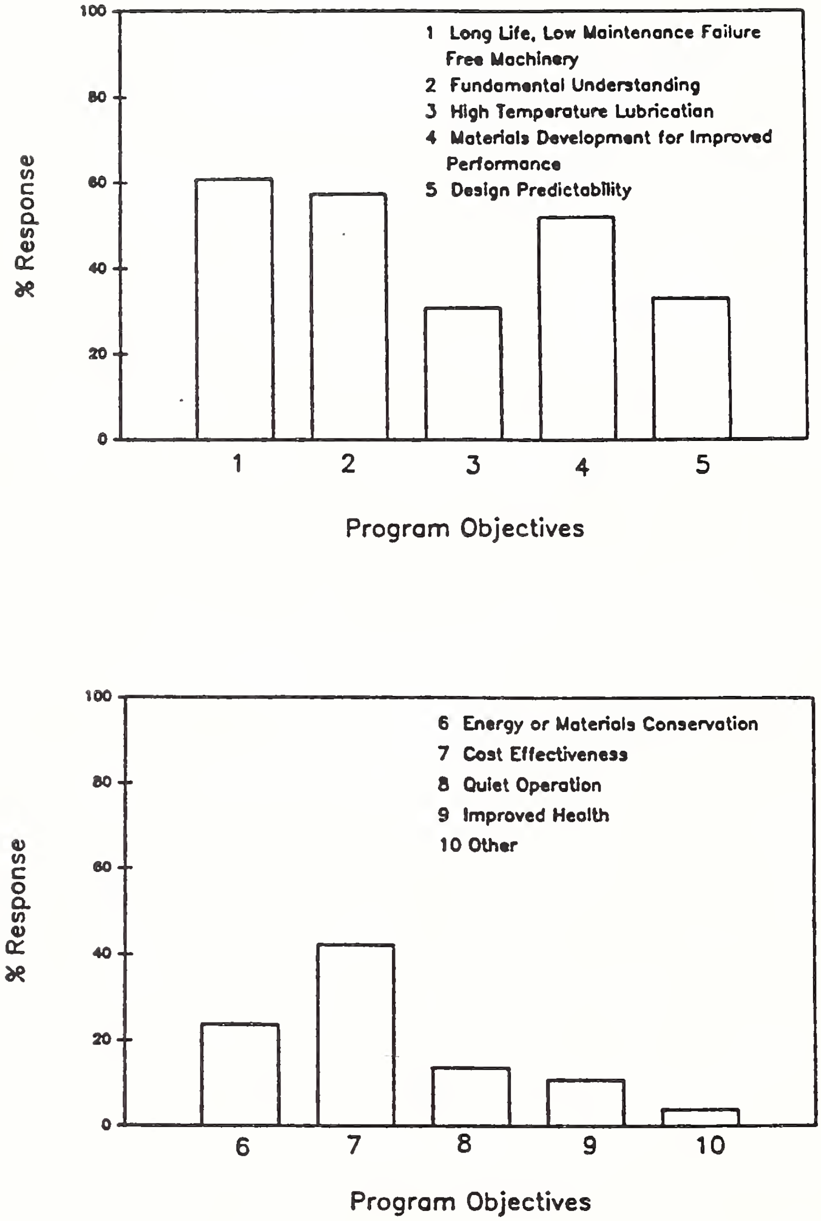
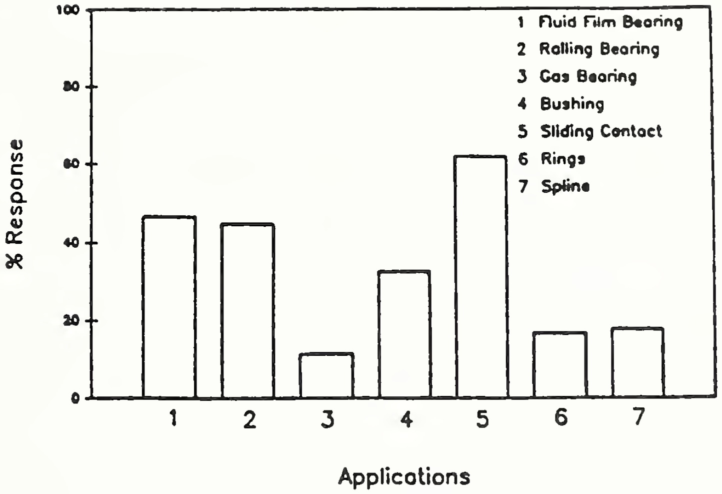
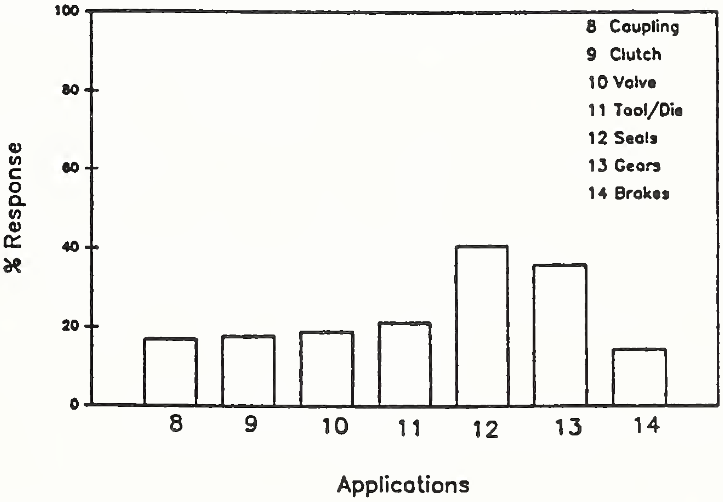


Figure 4. Primary program objectives are long life, low maintenance, failure free machinery, fundamental understanding and materials development for improved performance.





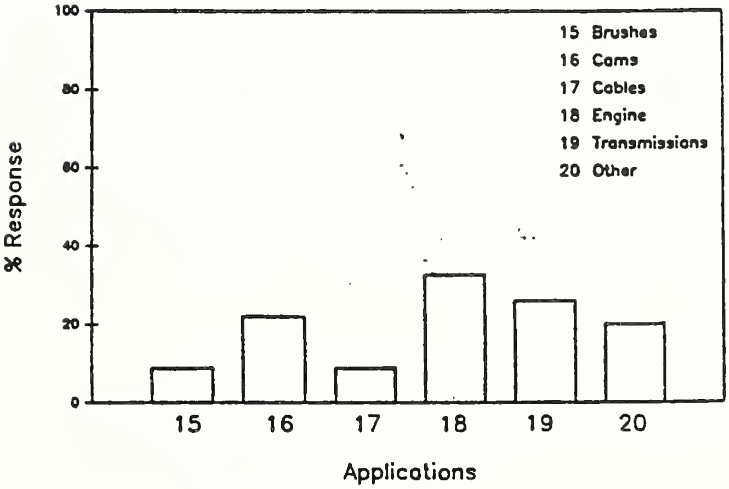


Figure 5. Major applications of interest to respondents include sliding contacts, fluid film, bearings, rolling element bearings, seals and gears.

and cutting, magnetic recording, orthopedic implants, electrical contacts, and tire-wheel friction and wear. The trend that was most apparent from the study is that tribology is being driven by specific needs that arise from the requirements of advanced development projects rather than by systematic advances in the field.

Almost 80 percent of the respondents indicated that metals are their material of primary interest (Figure 6). Ceramics, polymers and coatings, are also of major interest. A large number are working or interested in fluid lubricants, as well as solid lubricants. Other materials such as greases, additives, carbons and elastometers are also of interest in tribological applications. Analysis of the experimental conditions used in the research projects indicated that most of the important variables are being studied in the research projects, the summary of the results are given in Figures 7 to 10.

C. Analysis of Tribology Research Projects

The purpose of the preceding section was to analyze the current interest in tribology. The second page of the questionnaire requested descriptive information on basic and applied research projects. Fifty-one percent of the respondents submitted descriptions of basic and applied research.* In order to determine what type of research is being done these

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*The research descriptions that were submitted are reproduced in Appendix 3.

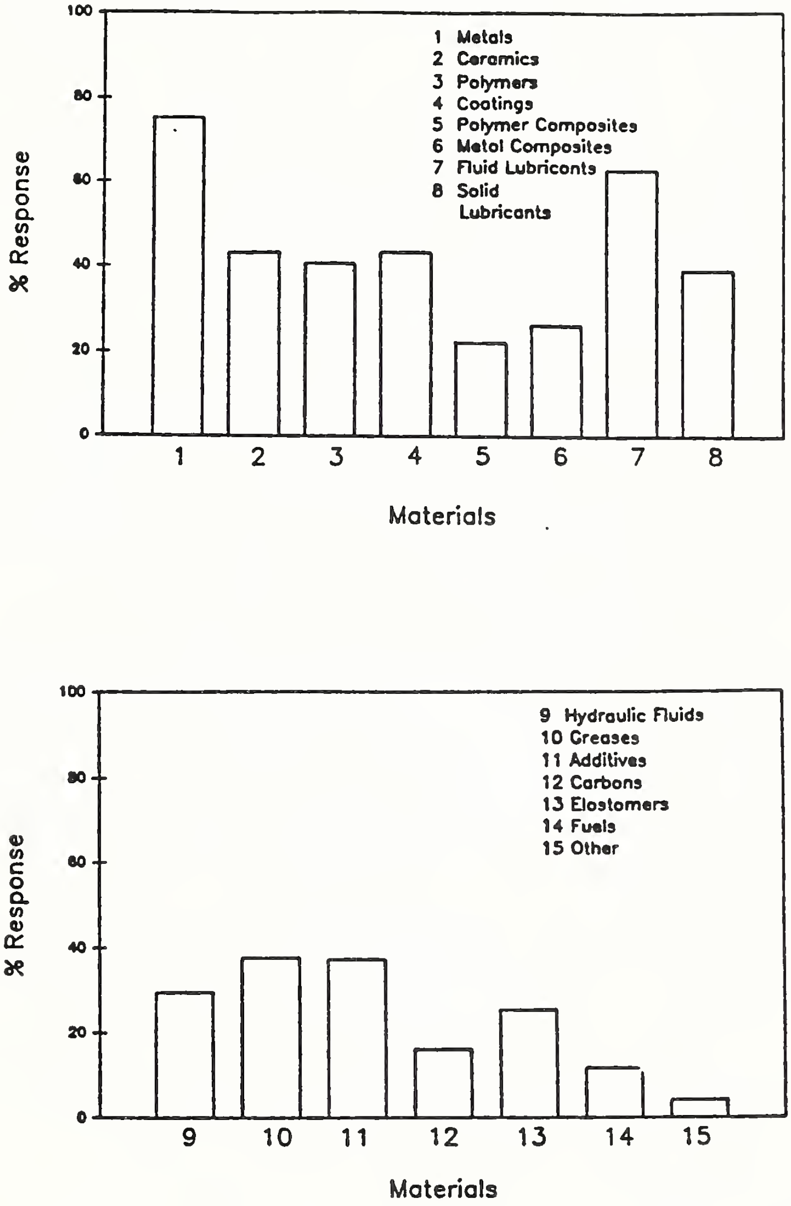


Figure 6. Metals and fluid lubricants are of primary interest; but ceramics, polymers, coatings and solid lubricants are also of interest.

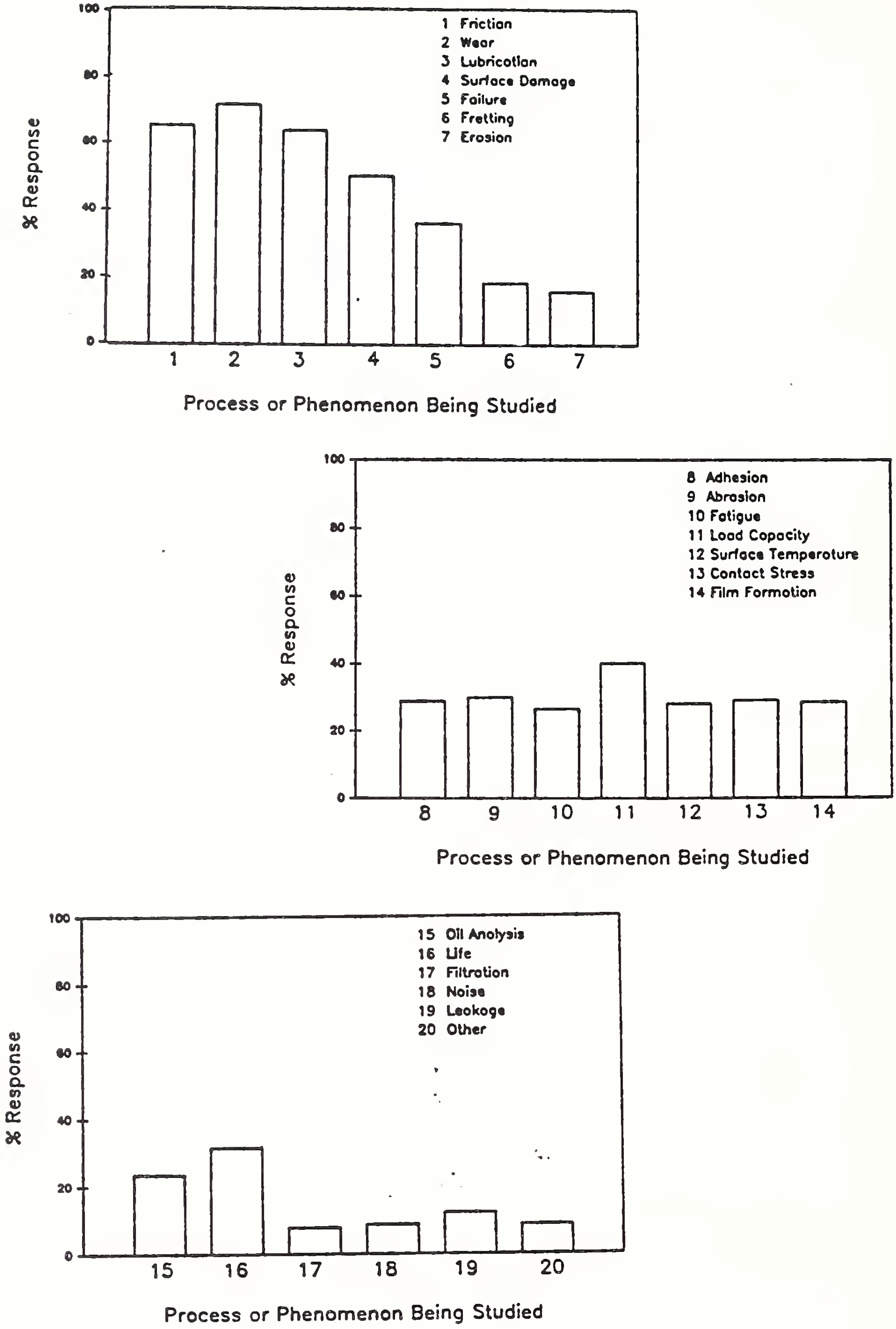
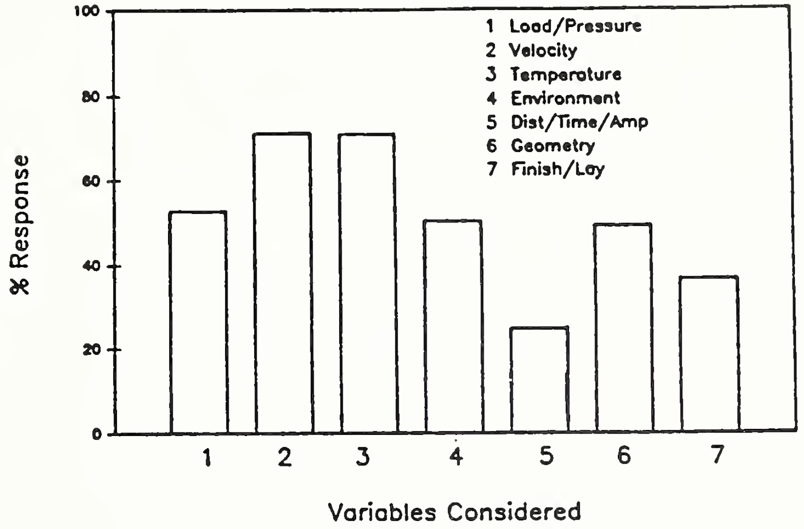


Figure 7. Most important tribological phenomenon or processes are being studied.



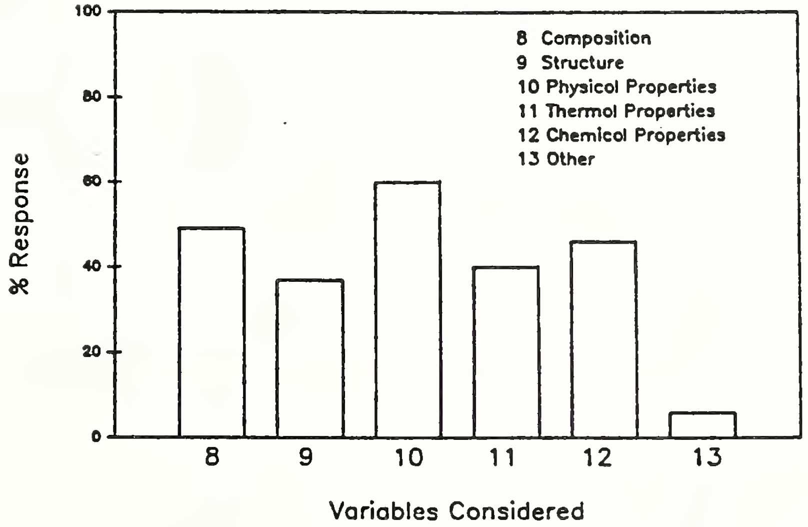


Figure 8. All the major test variables are considered in the research programs.

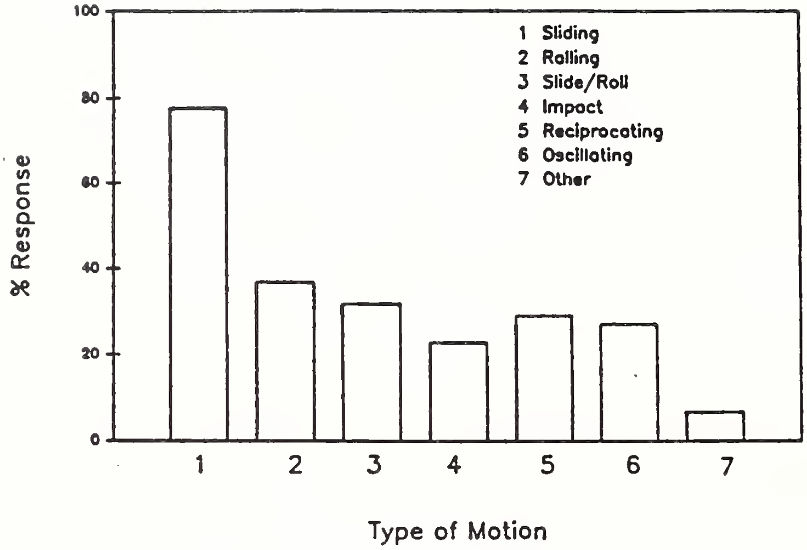


Figure 9. Sliding motion is predominant in the research projects.

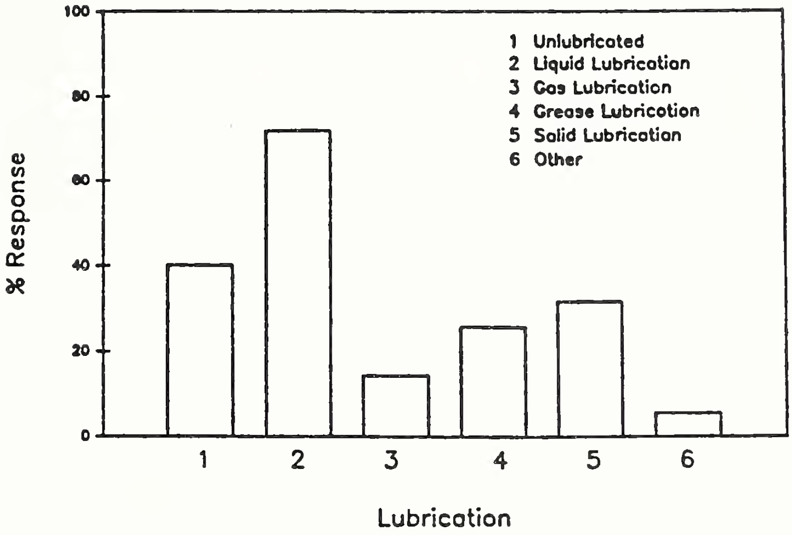


Figure 10. Most research projects are conducted under liquid lubrication.

descriptions were analyzed, and were classified as development, applied research and fundamental research. Approximately 46 percent dealt with research that is focused on development, i.e., the outcome in 6 months or a year is a particular product or a component. Approximately 29 percent dealt with applied research that would provide solutions to current engineering problems to be implemented in about 2 to 3 years. Approximately, 24 percent of the researchers indicated that they are working on fundamental research, i.e., research which advances knowledge rather than being directed toward specific applications. However, an analysis of the results indicated that most of this work was directed toward making incremental advances. Very little innovative research is being conducted that would introduce new ideas or approaches to the field.

In a recent symposium at the National Science Foundation the future research needs in tribology were discussed by twenty distinguished tribologists [6]. It is instructive to compare major recommendations from that symposium with the assessment of the research projects in the present survey. The major recommendations from the NSF symposium were that research should focus on: predictive models for friction wear and failure, microscopic and chemical aspects of lubrication, mechanisms and methods to prevent wear at microscopic levels, and materials and lubricants for high temperature applications. Analysis of research descriptions in this database revealed many examples of research activities or interest in materials and lubricants for high temperature applications, but the level of activity or interest in the other recommended areas was not strong. These areas are extremely important and there is a need for additional research. For example, the survey did not indicate much development work on predictive models, although this activity has been the subject of several meetings and workshops in the past 2 to 3 years [7,8].

Another observation from an analysis of the database is that the universities are becoming more involved in applied research. This may be influenced by the availability of research funds from industry and limitations of funds from the federal government. Since industry is more interested in advanced development and applied research than basic research, the direction of academic research is being changed.

Conclusions

1. A useful database has been developed which has potential for program planning, for avoiding duplicate research projects, for monitoring research trends, and for identifying experts or research projects in specific areas. To be of continuing value, however, the database must be updated on a regular basis.*

2. The level of basic research in advancing the frontiers of knowledge in tribology is extremely limited.

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* If you would like your activities included please fill out a copy of the questionnaire listed in the Appendix 2 and return it to: Mr. Allan B. Hughes, Executive Director, ACTIS, Inc., 1118 Highgate Road, Wilmington, Delaware 19808.

3. Fundamental research is being directed toward understanding interface phenomena, but there are few efforts directed toward developing predictive models.

4. Critical evaluation of the survey results suggest that there is a strong interest in applied research in tribology even at universities.

5. Primary program objectives in tribology activities are long life, low maintenance, failure free machinery, fundamental understanding and materials development for improved performance.

6. There is very little research being carried out on composite materials; metals are of primary interest for tribological application, but ceramics, polymers and coatings are being seriously considered.

Acknowledgements

The authors gratefully acknowledge financial support from the DOE-ECUT Tribology Program, the Tribology Program of NSF, the U.S. Army and Air Force, and the Tribology Program of NIST. The technical and financial support of ASME and STLE is gratefully acknowledged. Financial support from Industrial Tribology Institute for data entry is acknowledged. The authors would like to thank Ms. Martha James for her assistance on the research-in-progress database.

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8. "Workshop on Wear Modeling," Argonne National Laboratory, June 16-17, 1988.

Appendix 1

Description of ACTIS Database Components

The NUMERIC DATABASE will consist of critically evaluated numeric data on the basic properties and tribological performance of materials, lubricants, components, and systems. A wide range of tribological data will be covered, including subjects such as material properties and performance data of tribocomponents and tribosystems. Data in each of the areas will be critically evaluated by tribology experts who will review, distill, and compile a listing of evaluated 'best-judgment' parameters and properties in a standardized format.

The DESIGN DATABASE will consist of a selector guide for materials, lubricants and components, design analysis programs for tribocomponents and tribosystems, design calculations and failure diagnostics. These computer codes will be accessed through an expert system front-end for the non-tribologist. Some of the codes are available now but will need to be examined and validated prior to incorporation into ACTIS.

The NEWSLETTER DATABASE will be a communication link. It will consist of electronic mail as well as a hard copy newsletter. The newsletter database will serve as an exchange of old and new technical information including latest research results in tribology, meeting notices, calls for papers, requests-for-proposal, new products, book reviews, and summaries of pertinent technical topics.

The BIBLIOGRAPHIC DATABASE will be designed so that tribologists, materials scientists, design engineers, librarians and other information specialists, and students can search bibliographic references to the literature through a single point of entry, a so-called "gateway". This database will also serve the needs of the broad industrial community so that technology transfer can be more readily accomplished.

The RESEARCH-IN-PROGRESS DATABASE will contain abstracts of current, unpublished tribology research being conducted by government laboratories, industry, universities, and research institutes. The initial source for this database is described in this paper.

The PRODUCT AND SERVICES DIRECTORY DATABASE would provide a source of commercially available tribology products and related services most often used by application, maintenance, design engineers and purchasing agents. The database will contain information on tribocomponents, tribosystems, materials, and lubricants, as well as available services such as consultation and maintenance services.

Appendix 2

SURVEY TO ASSESS THE CURRENT LEVEL OF TRIBOLOGY RESEARCH AND DEVELOPMENT ACTIVITIES IN THE UNITED STATES

Name:
Affiliation:
Address:

Telephone Number:

Is Tribology your main area of activity? ________ Yes ________ No
If NO, please identify your main area of activity. ______________________________

(Please Circle All Appropriate Answers)

TYPE OF ACTIVITIES

1. Basic Research
2. Applied Research
3. Design and Development
4. Research/Design Supervision
5. Other (Please Specify)

GENERAL AREA OF INTEREST

1. Fluid Film Lubrication
2. Friction and Wear
3. Boundary Lubrication
4. Physics and Chemistry of Surfaces
5. Lubricants (Solids or Liquids)
6. Tribo-Materials and Coatings
7. Failure Analysis and Diagnostics
8. Tribological Components
9. Tribological Systems
10. Manufacturing and Materials Processing
11. Other (Please Specify)

PROGRAM OBJECTIVES

1. Long Life, Low Maintenance Failure Free Machinery
2. Fundamental Understanding
3. High Temperature Lubrication
4. Materials Development for Improved Performance
5. Design Predictability
6. Energy or Materials Conservation
7. Cost Effectiveness
8. Quiet Operation
9. Improved Health
10. Other (Please Specify)

APPLICATIONS

1. Fluid Film Bearing
2. Rolling Bearing
3. Gas Bearing
4. Bushing
5. Sliding Contact
6. Rings
7. Spline
8. Coupling
9. Clutch
10. Valve
11. Tool/Die
12. Seals
13. Gears
14. Brakes
15. Brushes
16. Cams
17. Cables
18. Engine
19. Transmissions
20. Other (Please Specify)

MATERIALS

1. Metals
2. Ceramics
3. Polymer
4. Coatings
5. Polymer Composites
6. Metal Composites
7. Fluid Lubricants
8. Solid Lubricants
9. Hydraulic Fluids
10. Greases
11. Additives
12. Carbons
13. Elastomers
14. Fuels
15. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name:

Affiliation:

Address:

Telephone:

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED: 1. Friction 2. Wear 3. Lubrication 4. Surface Damage 5. Failure 6. Fretting 7. Erosion 8. Adhesion 9. Abrasion 10. Fatigue 11. Load Capacity 12. Surface Temperature 13. Contact Stress 14. Film Formation 15. Oil Analysis 16. Life 17. Filtration 18. Noise 19. Leakage 20. Other (Please Specify)	TYPE OF MOTION: 1. Sliding 2. Rolling 3. Slide/Roll 4. Impact 5. Reciprocating 6. Oscillating 7. Other (Please Specify)
VARIABLES CONSIDERED: 1. Load/Pressure 2. Velocity 3. Temperature 4. Environment 5. Dist/Time/Amp 6. Geometry 7. Finish/Lay 8. Composition 9. Structure 10. Physical Properties 11. Thermal Properties 12. Chemical Properties 13. Other (Please Specify)	LUBRICATION: 1. Unlubricated 2. Liquid Lubrication 3. Gas Lubrication 4. Grease Lubrication 5. Solid Lubrication 6. Other (Please Specify)

Appendix 3

Descriptions of Research Projects Submitted

The research descriptions that were submitted as part of the survey were reproduced directly without any editorial changes to preserve the accuracy of the contents. These are arranged in the alphabetical order according to the respondents surname. A small number of the research descriptions contained information that could be construed as commercialism. These were not reproduced in the appendix, although the information was used to determine the overall research directions in tribology.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: George G. Adams
Affiliation: Professor of Mechanical Engineering
Address: Northeastern University, 334 SN
Boston, MA 02115
Telephone: (617) 437-2982

The sliding of one mechanical element over the surface of another results in high contact stresses and temperature fields which can lead to wear or even to fracture of one of the components. These phenomena can be important in unlubricated sliding contact or with lubricated sliding surfaces which exhibit asperity contact. In this research project, the stress and temperature fields due to sliding contact will be determined for various two- and three-dimensional geometries which include cracked and layered media. Although the uncoupled theory of thermoelasticity will be utilized, the temperature distribution does depend upon the stress field due to the generation of heat at the sliding interface. The solution method will involve the use of integral transforms which will be aided by the use of a symbolic interpreter language. The resulting integral equations will be solved numerically for the stress and temperature distributions. This will lead to a better understanding of the role of friction, material properties, thermal effects, and speed on the resulting stress distribution and on the associated phenomena of wear and fracture.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

④ PROJECT TITLE: Damage Sustained by a Rolling Bearing Due to a Combination of Static and Cyclic Loading in Compression.

Name: Arthur Akers
Affiliation: Iowa State University
Address: 2106 ME/ESM Bldg.
Telephone: (515)294-5782

Experimental work is being performed to delineate the static life of rolling element bearings used in dormant or semi dormant machinery when no lubricant is being supplied to the bearings. Examples of such dormant or semi dormant equipment under load are listed below.

a) The continuous static load imposed upon wheel and transmission bearings of a parked car (due to the vehicle weight or parking area incline on which is superimposed a dynamic load as a result of vibrations caused by continuous or intermittent traffic in the vicinity.

b) Household appliances (these devices are used only intermittently and the lubricant film is rejuvenated only at infrequent intervals.)

c) Workshop or toolroom machinery lying idle between work shifts. These idle periods can be up to 16 hours per day, and in a vibration environment.

d) Toolroom machinery precision attachments such as dividing heads or grinding quills which are mounted on their parent machine for long periods without being used, but nevertheless exposed all the time to the vibrations of the "parent machine" or of neighboring machinery at work.

The experimental rig has been designed with some care in order to enable loadings of the type required to be imposed.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

③ PROJECT TITLE: The Formulation and Execution of Predictive Maintenance Techniques for Turbine Journal Bearings.

Name: Arthur Akers
Affiliation: Iowa State University
Address: 2106 ME/ESM Bldg
Telephone: (515)294-5782

Every oil-lubricated bearing surface generates particles. During the passage of time, there is usually a pattern of change in five properties of the wear particles. Changes in these properties are described below.

1. The concentration of the particles within the oil increases.
2. The size of particles increases from about 10 μm up to 50 μm (or larger).
3. The type of particle changes, since the manner in which particles have been dislodged changes (metal can be removed by means of spalling, fretting, abrasion, or corrosion activity).
4. The composition of the debris changes, and the bronze or parent metal become present in the debris.
5. The rate of debris deposition increases.

At the point where abnormal, unacceptable wear occurs, the wear-particle concentration-increase rate may increase by an order or more, and the particle size will increase suddenly by the amount indicated in change two above. Predictive maintenance is to be performed on the turbine journal bearings used in the physical plant of ISU. It is proposed to provide means of sampling oil feed and drain lines so that the debris content can be evaluated by means of a DR II Ferrograph particle counter (planned for purchase.) As a direct result of the work it should be possible to establish a wear data base for each bearing. This data base will be an important diagnostic tool for determining when maintenance, replacement or bearing re-design should be performed. Additional thermometry will be installed to determine the relationship between the statistically established "wear base" and bearing temperature history.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
[✓ 16. Life]
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

② PROJECT TITLE: Tribology of Axial Piston Port Plates.

Name: Arthur Akers
Affiliation: Iowa State University
Address: 2106 ME/ESM Bldg.
Telephone: (515)294-5782

Previous investigations by the above Investigator into the mathematical modeling of an axial piston pump showed that the leakage flow between bearing and port plates and end casing increased as ~~a~~ the square of the pump outlet pressure(1). This behavior is inconsistent both with the properties of flow through an orifice with significant inertia (Q propl to $\sqrt{P}$) and with flow that is purely viscous (Q prop to P). A visit to a pump manufacturer revealed that the areas of the lands on the plates and their configuration were determined by a self-imposed design requirement that the plates have a clamping force as a delivery pressure increases.

The leakage is being investigated since optimization of the plate geometry should result. This optimization will take place with respect to minimum friction, maximum wear, and minimum leakage. Minimum leakage results, of course, in maximum pump volumetric efficiency. The work will entail modeling of the flow mechanics by the use of finite elements.

1. Zeiger, G., and A. Akers, "Torque on the swashplate of an axial piston pump," J. Dyn. Sys. Meas. Control, 107(3):220-226 (1985).

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

① PROJECT TITLE: Tribological Conditions in a Piston and Cylinder System of an Axial Piston Motor.

Name: Arthur Akers
Affiliation: Iowa State University
Address: 2106 ME/ESM Building
Telephone: (515)294-5182

The objective of this project is to investigate one of the tribological aspects of the oper tion of axial piston motors. Thus the lubrication mechanism of the piston cylinder bore clearance is to be analyzed. The effects of the piston's reciprocating and rotational motion upo the pressures, clearances, and flow rates over the developed piston surface will be examined. Then the appropriate values of the wear criterion pV will be determined and an investigation will follow as to how changes in geometry will affect this wear criterion (and, implicitly how they will affect the wear rate.) In order to do this, the tribological conditions of the clearances between an individual piston and its respective cylinder bore of an axial piston motor will be described. The mechanical loads imposed on an individual piston, due to the operation of the motor, will be calculated and shown to put the piston into a tilted configuration with respect to the cylinder bore. The components of the total lubricated mechanism present in the piston and cylinder clearances will be described and analyzed. Changes in values of clearance, flow and pressure due to changes in geometry will also be investigated in order to provide data banks for axial piston motor design. By understanding the factors that determine wear rates of these motors, it is hoped that the designer can modify the motors and hence make an already useful mechanism even more versatile and dependable.

The form of the Reynolds equation which has been developed for this project will enable other similar complex configurations to be analyzed.

As a final part of the project it is envisioned that experimental work will be performed in order to guide and complete the solutions to the Reynolds equation used for different configurations.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Magnetic Bearings For Rotoating Machinery

Name: Dr. Paul E. Allaire
Affiliation: Universtiy of Virginia
Address: Mechánical Engineering Dept., University of Virginia
Telephone: (804)-977-4468

Magnetic bearings are beginning to come into industrial use for compressors, pumps, turbines, aircraft engines and other rotating machines. Our research group has designed, built, tested, and analyzed magnetic bearings in our laboratory. A four magnet bearing has been run in a flexible rotor up to 10,000 rpm over three critical speeds. A method of analysis for these bearings ahs been developed which gives critical speed predictions to within 5% in the vertical direction. Currently magnetic bearings are being installed in a canned pump to increase bearing relability over that with conventional sleeve bearings. A digitally controlled magnetic bearing has also been developed and tested. Our gaols include future development of low cost magnetic bearings for a wide range of applications and advanced design of magnetic bearings for aircraft and compressor applications.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Squeeze Film

Name: Charles W. Allen
Affiliation:
Address: Mech Engin Dept. Calif State Univ. Chico CA 95929
Telephone: 916 895 4383

Squeeze Film between plane surfaces both hydrodynamic & EHD

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
[✓ 5. Dist/Time/Amp]
6. Geometry
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Laboratory/Analysis of Draw + Iron Fluids for the Aluminum Can Industry

Name: Richard Almen

Address: Adolph Coors Co Golden Co 80401

Telephone: 303-277-2867

Affiliation: Adolph Coors Co. + A.S.L.E.

Project Goals - Correlation of lab analysis and physical testing with production results.

Methods - Modified ASTM standard methods

Findings - inconclusive

Future Evaluate new methods

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
16. Life
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)
Drawing + Ironing

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: ADVANCES IN CUPPING TECHNOLOGY

Name: RICHARD ALMEN
Affiliation: ADOLPH COORS Co. + A.S.L.E.
Address: ADOLPH COORS Co. GOLDEN Co. 80401
Telephone: 303-277-2867

Project Goal: Reduce Costs on Draw and Iron process for producing Aluminum cans

Method: Apply improved lubricant to coil stock prior to Fabrication process

Findings: 66% reduction of lubricant in over all process

Future: Implementation of system plant wide

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
16. Life
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify) Drawing + Ironing

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Taylan Altan
Affiliation: The Ohio State University
Address: ERC for Net Shape Mfg., 1971 Neil Ave., Columbus, OH 43210
Telephone: 614/292-5063

Project Title: Investigation of Die Wear in Metalforming

The goals of this study are to understand and predict the quantitative relationships between major process variables and abrasive die wear in cold and hot forming processes such as upset forging and extrusion.

For given die and workpiece materials and process conditions (deformation speed, temperatures, lubrication, etc.), the approach is to predict the temperatures, stresses, velocities, and the total amount of material displacement at various locations at the die material interface. For this purpose the FEM based code ALPID (Analysis of Large Plastic Incremental Deformation) is used. These predicted details of process conditions are then compared with experimental die wear data in order to establish a statistical relationship between measured wear and process variables.

So far in our study, this methodology has been applied in cold, warm and hot upsetting, with some success. Other researchers conducted similar investigations in hot forging. Our work will be expanded to forging, extrusion, and other forming processes.

Other participants: Dr. Amit Bagchi, Assistant Professor, and Mr. Omer Vardan, Graduate Student.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
[✓ 7. Erosion]
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Oil Life Extension

Name: Michael Ames
Affiliation: Northern Natural Gas
Address: 2130 N. Hwy 83 Liberal, KS 67901
Telephone: 316-624-1911

Operational Improvement Project

Project involved generating a study to evaluate life extension procedures for Gas Engine Oils in a large natural gas transmission company. Results are: projected tripling of oil life; creation of a central oil analysis lab; and field oil analysis labs; construction of a large bulk used oil reclaimer; and installation on engine of oil + equipment life extending filtration and Degassing units.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
16. Life
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Arnold Anderson
Address: 11314 Mayfield, Livonia, MI 48150
Telephone: (313) 337-5059
Affiliation: Ford Motor Co.
Engg & Mfg. Staff

SPECIFICS ARE CONFIDENTIAL

GENERAL AREAS ARE

BRAKE/CLUTCH DESIGN/DEVELOPMENT METHODOLOGY
" " INSTRUMENTATION/DATA ACQ. DEVELOPMENT

NON-ASBESTOS FRICTION MATERIALS RESEARCH

BRAKE DIAGNOSTICS, ARTIFICIAL INTELLIGENCE

SURFACE CHARACTERIZATION FOR TRIBOLOGY

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
[✓ 5. Failure]
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

3/27/87

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: DR. MORTON ANTLER
A.T.&T. BELL LABORATORIES
Address: 6200 EAST BROAD STREET
COLUMBUS, OHIO 43213
Telephone: (614) 860-3403

Affiliation:

This project aims to establish guidelines for ① the selection of contact materials and lubricants and ② contact designs for separable electronic connectors, printed circuit boards, and related components and devices such as slide switches and instrument slip rings. The guidelines are based on tribological properties which fall within the scope of this survey; but other factors are included such as the electrical properties of the materials, their corrosion resistance, and the effects of surface treatments on their performance. Reliability studies are included in this work.

Among the materials of interest are noble and non-noble electrodeposits, clad metals, and weldments; underplatings such as nickel and nickel alloys which may affect performance; and lubricants (synthetic oils, petroleum oils, waxes, greases, etc). Multilayer coatings are frequently used as contact materials. Metallic film lubricants are also included in these studies.

Tribological properties are considered to include: friction, the various common wear processes such as adhesion, abrasion, brittle fracture wear, fretting, and surface interactions which produce frictional polymers.

The tools most used are rider-flat and crossed rod bench wear machines, and modern inspection instruments are employed to characterize surface changes; these tools include the SEM, EDAX, Auger, etc.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)]
Electrical contact resistance

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
[✓ 13. Other (Please Specify)]
Electrical performance

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
[✓ 6. Other (Please Specify)]
adventitious (or accidental) environmentally related

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: John P. Arena, P.E.
Affiliation:
c*p
Address: Downsville, LA 71234
Telephone: (318) 644-2246

The object of this investigation has been to find a working math model for dynamic face seals.

Tests were conducted to obtain data. The data showed the following:

1. A change in the closing force at constant pressure, temperature and RPM, resulted in a change in the leakrate, film thicknesss and torque.
2. A change in the pressure gradient while maintaining constant closing force, temperature and RPM resulted in a change in the leakrate, film thickness and torque.
3. A change in RPM at constant closing force, pressure and temperature resulted in a change in the leakrate, film thickness and torque.

The future direction requires the development of a math model that relates the variables as was noted in actual tests. Present math models do not do this. In fact you will have a difficult time locating technical papers with data sets as noted above. This is a necessary requirement to prove the validity of the math model.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Study of Tribological Coatings and Their Mechanisms of Formation

Name: Dr. Franco Arezzo
Affiliation: Singer-Kearfott Division
Address: 1150 Mc Bride Ave., Little Falls, N. J. 07424
Telephone: (201) 785-2547

The goal of our studies is to reach a basic understanding of the mechanisms of tricresyl phosphate (TCP) and other additives in producing desirable tribological coatings under boundary lubrication conditions. The interactions of TCP with steel surfaces have been studied using electron spectroscopy for chemical analysis (ESCA) and microoxidation methods. Recent results showed that it is possible under certain experimental conditions to produce a useful phosphate coating. The mechanisms of TCP dissolved in hydrocarbon oil are being clarified. Preliminary experiments show that the resultant coating is quite different from that of the TCP.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
[✓ 6. Fretting]
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
[✓ 13. Other (Please Specify)] Reaction Kinetics

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: INVESTIGATION OF WEAR MECHANISMS OF PSZ AT HIGH TEMPERATURES AND EXHAUST GAS ENVIRONMENT

Name: Dr. V. Aronov
Affiliation: Illinois Institute of Technology
Address: 10 W. 32nd Street
Telephone: (312) 567-3181

This research was devoted to an investigation of the wear mechanisms of magnesia and yttria partially-stabilized zirconia in ceramic/ceramic and ceramic/metal sliding-contact tribological systems at high temperature. Scanning electron microscope, optical microscope and X-ray dispersion and defraction analyses were used for identification of wear mechanisms. Surface geometry and morphology and wear were determined as functions of sliding distance, nominal contact pressure, sliding speed and mechanical properties of the specimens (hardness and fracture toughness). It was found that the wear of ceramics rubbed against ceramics at room temperature may be attributed to intensive plastic deformation of surfaces resulting in low cycle fatigue. The wear mechanism of ceramics rubbed against metals was by polishing and surface fracture, while that of metals was adhesive transfer of material on to ceramic surfaces. Wear rates were independent of the mechanical properties of metallic samples.

Experimental investigation of the wear behavior of magnesia partially-stabilized zirconia rubbed against itself showed that up to three orders of magnitude increase in wear resistance can be achieved in a particular temperature range, depending on both sliding speed and the ambient temperature. XRD analysis revealed that a thermally-induced phase transformation takes place on the frictional interface. Surface analysis showed that wear rates at maximum wear resistance are controlled by the crack generation kinetics rather than by crack propagation kinetics.

(continued on attached page)

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

A phenomenological model is presented that provides an explanation for the wear-temperature behavior of Mg-PSZ. The model is based on the following chain of events that takes place on the frictional interface: spatial overheating of the surface areas, phase transformation of the overheated areas, cooling, volume expansion, and development of a compressive stress field in the near surface layers.

The wear rate of yttria partially-stabilized zirconia was controlled by fracture at all temperatures investigated.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Wear resistance of the Dynamically Loaded Boundary lubricated Sliding Contacts.

Name: V. Aronov
Affiliation: Illinois Institute of Technology
Address: 10 W. 32nd Street
Telephone: (312) 567-3211

This research is devoted to an experimental and theoretical investigation of wear of steel under forced oscillations of applied load in boundary lubricated sliding contact.

In theoretical analysis, the main concepts of the wear model based on asperity interactions, developed by Halling and modified by Finkin, were incorporated. To explain effects of the dynamic loading on wear of metals, Miner's theory was employed to account for a cumulative damage in the dynamically loaded sliding contact.

A special pin-on-disk type wear apparatus, which enabled continuous control of the dynamic loading parameters, has been used in the experimental investigation. Wear rates and surface roughness were measured for various combinations of static and dynamic loading parameters. A wear equation which related wear to the parameters of dynamic loading (mean load, amplitude and frequency of the load oscillation and sliding velocity) has been derived.

It has been shown both by experimental investigation and theoretical analysis that wear is an increasing function of the mean value of the applied load, amplitude of the load oscillation and ratio of frequency of load oscillation to the sliding velocity.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Analytical Study of Tool Wear in Machining

Name: A. Bagchi
Affiliation: The Ohio State University
Address: Ind. Engr. Dept., 1971 Neil Ave., Columbus, OH 43210-1271
Telephone: (614) 292-4565

A complete understanding of the machining process and cutting tool wear requires a synthesis of both analytical and experimental studies of the mechanics of deformation and chip flow, tool and work material properties and interfacial heat transfer. This research proposes an interdisciplinary approach to metal cutting in order to predict the cutting tool forces, temperatures at the chip-tool interface and ultimately tool wear.

The work involves the development of numerical and finite element models for orthogonal cutting to obtain the stresses and temperatures at the interface. Validation of analytical results will be attempted by correlation with experimental data. Workpiece materials such as SAE 1020 and aluminum alloy 6061, which tend to develop crater as well as flank wear, will be studied. Characterization of the work hardening and deformation heating effects for the high strain rate conditions in machining will be a contribution. Metallographic examination of tools will be carried out in order to substantiate the wear volume predicted from analysis.

The goal of this research is to improve tool life by establishing appropriate machining conditions and reducing the requirement of expensive experimentation for tool wear prediction.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Effect of microstructure and mechanical properties on the erosion of 18 Ni 250 maraging steel and Ti-6% Al-4% -alloy

Name:
Address:
Telephone:

Prof. Shyam Bahadur
Mechanical Engrg. Dpt.
Iowa State University
Ames, Iowa 50010

Affiliation:

(515) 294-7658

Goals: The research goals are: (1) studying the erosion behavior of two precipitation hardening alloy systems; (2) investigate the dependence of erosion on microstructures and mechanical properites; (3) correlate erosion with mechanical properties; and (4) study erosion mechanisms.

Methods of Approach: The two alloy systems are heat treated in various ways and the erosion using a sand blast type of experimental setup is being studied for each heat treatment condition. The erosion behavior is also being studied as a function of velocity and impingement angle. The mechanical properties (tensile and hardness) are also being measured for each heat treatment condition. The erosion behavior is being correlated with both microstructure and mechanical properties.

The results on maraging steels have indicated that erosion depends upon the state of precipitation hardening and austenite reversion. There is an inverse relationship between erosion rate and percent area reduction.

The work on Ti-alloy is still in progress.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
[✓ 7. Erosion]
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify) [✓ Angle]

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Presidential Young Investigator Award: Predicting the Reliability and Failure of Electrical Connectors

Name: Dr. Michael D. Bryant
Affiliation: North Carolina STate Univ.
Address: Dept. Mech. & Aero. Eng.
NCSU Raleigh, NC 27695-7910
Telephone: (919) 737-3241

The proposer is analyzing the contact physics associated with the type of electrical connectors found in most computers. Here the objective is to predict the time changing increase of electrical resistance due to the formation of surface films on the contacting surfaces of the connector. The connector is composed of many very small contacting spots. The current flowing through the connector is distributed through these parallel spot-circuits. The spots originate from asperity to asperity contact between the mating connectors.

When the contact is made, currents are constricted through these spots which are randomly distributed. As time progresses, the environment may react with the connector metals and form insulating films around the spots. This elevates the overall connector resistance and can result in noise added to the signal that passes through the connector. In the worst case the connector may cause the entire machine (computer, telecommunications gear) to fail.

This problem combines solid mechanics, the theory of electrical contacts, and surface chemistry. Surface properties such as surface roughness and waviness emerge as important factors. Experimental verification of the physical models is planned for the near future.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED

1. Friction
2. Wear
3. Lubrication
4. [✓ Surface Damage]
5. [✓ Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. [✓ Load Capacity]
12. [✓ Surface Temperature]
13. [✓ Contact Stress]
14. [✓ Film Formation]
15. Oil Analysis
16. [✓ Life]
17. Filtration
18. [✓ Noise]
19. Leakage
20. [✓ Other (Please Specify)] Film & Contact Resistance

TYPE OF MOTION

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED

1. [✓ Load/Pressure]
2. Velocity
3. [✓ Temperature]
4. [✓ Environment]
5. Dist/Time/Amp
6. [✓ Geometry]
7. [✓ Finish/Lay]
8. [✓ Composition]
9. [✓ Structure]
10. [✓ Physical Properties]
11. Thermal Properties
12. [✓ Chemical Properties]
13. [✓ Other (Please Specify)] Electrical Properties

LUBRICATION

1. [✓ Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: W. W. Gardner
Affiliation: Waukesha Bearings Corp.
Address: P. O. Box 798, Waukesha, WI 53187
Telephone: (414) 547-3381

Recent findings were published by W. W. Gardner and are:

"Performance Characteristics of Two Tilting Pad Thrust Bearings", Proceedings of JSLE International Tribology Conf., July '85.

> A tilting pad thrust bearing incorporating several changes, as compared to a current standard design, has been developed to provide greater load capacity. Design changes were made to the pad face geometry, the pad support design, and the load equalizing mechanism. Details of the new design features and the bases for their selection are described. Laboratory tests were run to establish operating characteristics to compare to those of a current standard design. Typical test data and comparisons are presented.

"Tilting Pad Thrust Bearing Tests - Influence of Three Design Variables", 13th Leeds-Lyon Symposium, Sept. '86.

> The purpose of this paper is to report the results of an extensive series of tests on a special tilting pad thrust bearing. The primary interest was to determine the effects on bearing performance of using circumferential pivot locations outside the normal range of 50 to 60% of the pad arc, from the leading edge. Secondary results were also obtained from tests with pad support disks of various diameters, and with pads of different thicknesses.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Joan D. Banks
Affiliation: Whirlpool Corporation
Address: Monte Road, Benton Harbor, MI 49022
Telephone: 616/926-5233

The tribology work done here at Whirlpool is VERY applied in nature. It is used primarily as a problem solving tool. Hopefully the introduction of databases available to design engineers will open tribological information to their use.

The lab here is equipped with several Falex testers. The bulk of the work has been on comparative lubricant testing and friction studies. Requests often come from Engineers solving component failure problems, or sometimes design engineers trying innovative materials applications.

We have an extensive compressor oil lubricity ranking and we are currently collecting data on a face seal system in the dishwasher where we have tested several different materials to determine the ones which will give the best overall performance.

The emphasis here will likely not change -- applying innovative technologies to our products is what life is all about.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
[✓ 4. Impact]
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
[✓ 13. Other (Please Specify)]

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Effect of Matrix & Filler on Dental Composite Resin Properties

Name: Mark W. Beatty,D.D.S.
Affiliation: Indiana Univ. Sch. of Dentistry
Dept. of Dental Materials
Address: 1121 W. Michigan St.;Indianapolis,IN 46202
Telephone: 317/274-3725

Tests on model composite resins intended for dental use will be conducted. Three parameters will be varied: type of matrix, volume fraction of filler and filler particle size. Composites will be formulated from four resin matrices, each with a different modulus of elasticity and toughness. These matrices will be systematically loaded with increasing volume fractions(five in all) of each of three fillers that differ in particle size(0.04 um agglomerated silica,2um glass and 15 um glass).Properties to be measured are:water sorption,hardness,toothbrush abrasion, sliding wear against hydroxyapatite, compressive strength and strain in slow compression. Toothbrush abrasion will be determined by brushing 6 x 12 mm cylindrical specimens in a mechanical brushing machine in a 1:1 water(by weight) slurry of CaCO$_3$. The specimens will be weighed,dimensions measured, brushed for 2 hours, reweighed, and volumeloss calculated on the basis of density values. SEM of the surfaces will be employed for evaluation of the abrasion process. Sliding wear will be tested on a pin and disc wear machine. The sliders are composed of synthetic hydroxyapatite which are machined to a diameter of 2 mm and the surfaces finished flat by 600 grit silicon carbide.The slider travels over the specimen under a 3kg load in a circular path of approximately 7 mm in diameter. The specimens consist of resin discs 15 mm in diameter x 2.5 mm thick. The specimens are run-in for 5000 cycles at 85 cycles/min and then the speed increased to 150 cycles/min for an additional 20,000 cycles. A stream of 37^{o}C water is directed onto the specimens throughout the test. Volume loss is estimated by taking width and depth measurements at six evenly-spaced regions on the wear track and then calculating the mean volume loss. Surfaces of the resin specimen and slider are then examined in the SEM for surface damage and transfer film.Longitudinal studies over 10k,15k,20k, 25k and 30,000 cycles are planned in order to observe any changes in the wear mechanism; pilot studies have indicated fatigue plays a major role later in the process.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tribological Characteristics of lube oil Basestocks

Name: M. ~~TAYEB~~ BENCHAITA
Affiliation:
Address: 1520 LAKEFRONT CIRCLE
Telephone: PENNZOIL PRODUCTS Co.
The Woodlands, TX 77380
Tel # 713 363 8032.

the major project is presently entitled "Lube oil Basestock Characterization." We are presently studying friction and wear characteristics, thermal and oxidative stability of Basestocks. Areas of interest include crude origin, processing steps, separation procedures, molecular structures, etc... Chemical structure and composition of basestock constituents, Aromatics, Saturates, "Polars" are being investigated. High Influence of "Polars" on Oxidative stability and Friction and Wear characteristics, has been identified. Inhibited Basestocks, fully formulated motor oils will be studied next.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

- [✓ 1. Friction]
- [✓ 2. Wear]
- [✓ 3. Lubrication]
- [✓ 4. Surface Damage]
- [✓ 5. Failure]
- [✓ 6. Fretting]
- 7. Erosion
- 8. Adhesion
- [✓ 9. Abrasion]
- 10. Fatigue
- [✓ 11. Load Capacity]
- [✓ 12. Surface Temperature]
- [✓ 13. Contact Stress]
- 14. Film Formation
- [✓ 15. Oil Analysis]
- 16. Life
- 17. Filtration
- 18. Noise
- 19. Leakage
- 20. Other (Please Specify)

TYPE OF MOTION:

- [✓ 1. Sliding]
- [✓ 2. Rolling]
- [✓ 3. Slide/Roll]
- 4. Impact
- 5. Reciprocating
- [✓ 6. Oscillating]
- 7. Other (Please Specify)

VARIABLES CONSIDERED:

- [✓ 1. Load/Pressure]
- [✓ 2. Velocity]
- [✓ 3. Temperature]
- [✓ 4. Environment]
- 5. Dist/Time/Amp
- [✓ 6. Geometry]
- [✓ 7. Finish/Lay]
- [✓ 8. Composition]
- [✓ 9. Structure]
- [✓ 10. Physical Properties]
- [✓ 11. Thermal Properties]
- [✓ 12. Chemical Properties]
- 13. Other (Please Specify)

LUBRICATION:

- [✓ 1. Unlubricated]
- [✓ 2. Liquid Lubrication]
- 3. Gas Lubrication
- 4. Grease Lubrication
- 5. Solid Lubrication
- 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Nonsynchronous perturbation testing of rotating shaft/fluid lubricated bearing system. Identification of fluid dynamic forces in bearings and fluid/solid interaction modes.

Name: Mr. Donald E. Bently, Dr. Agnes Muszynska - Affiliation: Bently Rotor Dynamics Research Corporation
Address: P.O. Box 2529, Minden, NV 89423
Telephone: (702) 782-3611 ext. 9674

The experimental and analytical study provided adjustments to currently used "bearing coeffecient" fluid dynamic force models. It also contributed to interpretation of fluid/solid interaction modes of vibrations unknown in classical modal analysis of mechanical systems. Survey of results is published in "Modal Testing of Rotor/Bearing System" by Dr. Agnes Muszynska, International Journal of Analytical and Experimental Modal Analysis, July 1986. Future studies will concentrate on identification of fluid force models for wider range of parameters (such as shaft eccentricities, bearing clearance/length effects, fluid inertia, lubricant pressure, temperature, non-conventional lubricants, etc.).

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)
[✓ 21] Vibrations

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)
[✓ 8] Rotating + precessing of the shaft

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
[✓ 5. Dist/Time/Amp]
6. Geometry
7. Finish/Lay
8. Composition
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Improvements in Rotor/Fluid Lubrication Bearing Stability Through Pressurization of Lubricant

Name: Mr. Donald E. Bently
Dr. Agnes Muszynska
Affiliation: Bently Rotor Dynamics Research Corporation
Address: P.O. Box 2529 Minden, NV 89423
Telephone: (702) 782-3611 x 9674

The goal of this research is to experimentally and analytically evaluate advantages of hydro-static (externally pressurized) fluid lubricated bearings supporting rotating shafts. Application of such bearings provide higher rotor stability. The study covers the analysis of lubricant inlet/outlet design solutions to improve bearing performance. Application of externally pressurized fluid lubricated bearings assure stable and controllable rotor operation, high efficiency and longer life of the rotating machine.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Oil Analysis

Name: Alan T. Barta
Affiliation: FMC Corp. C.E.L.
Address: 1205 Coleman Ave., Santa Clara, Ca. 95052
Telephone: (408) 289-2242

The objective of the Oil analysis Project at Central Engineering Laboratories is to provide high quality, standardized analytical services to various FMC Divisions. The intention is to extend the functional Life of manufacturing equipment and improve product quality. Tests routinely performed include: physical property determinations i.e. viscosity, pour and flash points, foaming characteristics, API density; chemical and contaminant composition, i.e. elemental analysis, organic analysis, particle size and distribution, wear metal accumulation, water content, fuel and coolant dilution of oils. Methods of analysis include: wet chemical, x-ray fluorescence spectrometry, atomic absorption spectrophotometry, fourier transform infrared spectrometry, optical and scanning electron microscopy, gas chromatography. Additional capabilities exist in metallography, mechanical and metallurgical engineering, computer science; robotics, artificial intelligence and applied mechanics. (These are other departments within CEL). Hopefully intended for the future is the acquisition of a spark emmission spectrometer.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

PROJECT TITLE: Product Tribological Research & Development

Name: John C. Bierlein, Ph.D., P.E.
Affiliation: Eaton Corporation
Corp. Research & Development - Detroit Center
Address: 26201 Northwestern Hwy, P.O. Box 766
Southfield, MI 48037
Telephone: (313) 354-2771

Eaton Corporation does have an active tribology program. The tribological project goals primarily are directed to improvements in current products or being involved with the development of new products within its core businesses. These products range from individual items within axles, brakes, clutches, differentials, engine components, gears and hydraulics, etc., to rather substantial subsystems. The methods of approach include a wide variety of product research and development techniques which are in keeping with project goals. Examples would be fixture testing, simulation and full component or product evaluations. Recent findings are being introduced into our products so as to be of benefit to our customers. The future directions will be to continue to conduct research and development to provide products with optimized lubrication and minimized friction and wear for improved performance and economies of operation of our products.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Modelling Break-in and Transitions in Friction and Wear

Dr. Peter J. Blau Nat. Bur. of Standards
NBS, B-261 Matls
Gaithersburg, MD 20899
301-975-6005

This project attempts to model the shapes, durations, and variability of friction coefficient versus time or cycle number curves based on an in-depth understanding of the phyisical processes going on in the sliding contact region. A mathematical representation of friction curves is being developed in a form which is flexible enough to allow the incorporation of existing or future models for sliding under dry or boundary lubricated conditions. Near-term break-in and long term, sudden transitions will be addressed. Certain physical effects such as subsurface deformation, surface finish, debris accumulation, transfer film formation, coating wear-through, change in dominant wear mode, and loss of lubricant effectiveness with time are to be integrated into the appropriate terms of the model.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

Control of Wear of Magnetic Media with Sputtered i-Carbon Overcoats

D.B. Bogy
ME Department UC Berkeley, Berkeley, CA 94720
(415) 642-2570

This work is concerned with the head/disk interface wear problem that occurs in hard magnetic disk drives. The read/write transducer is mounted on a slider that forms part of an air bearing against the rotating magnetic media disk. During the starting and stopping phases of the drive the slider comes into intimate contact with the disk on which the information is stored. The device must endure many tens of thousands of start/stops without appreciable wear.

In order to protect the new thin film magnetic media the industry has adopted a protective "diamond-like" carbon overcoat. The properties of this overcoat and the dependence of these properties on the fabrication process are still largely unknown. The object of this research project is to understand this tribological process and relate the process to the mechanical properties.

Recent papers based on this work are:

W-R. Chang, I. Etsion, D.B. Bogy, "An Elastic-Plastic Model for the Contact of Rough Surfaces", J. Tribology, to appear

_____,"Static Friction Coefficient Model for Metallic Rough Surfaces", J. Tribology, submitted

_____, "Adhesion Model for Metallic Rough Surfaces" J. Tribiolgy, submitted.

H-C. Tsia and D.B. Bogy, "Characterization of Diamond-like Carbon Films and Their Application as Overcoats on Thin film Media for Magnetic Recording, J. Vac. Sci. Tec., submitted.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
11. Load Capacity 1
12. Surface Temperature
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: WEAR TESTING OF OIL COUNTRY TUBULAR GOODS

Name: C. A. BOLLFRASS & K. D. CHELETTE Affiliation: THREAD TECHNOLOGY INTERNATIONAL
Address: 8800 JAMEEL STREET S 140; HOUSTON, TEXAS 77040
Telephone: 713 - 460 - 0292

Development of standard test method for test specimens made from steel or nickel based alloy tubes for investigation of materials, lubricants, coatings, finishes and load phenomena. Project calls for development of standard test specimens as well as statistical test method.

Initial program is about to finish and has been successful. Next program will consist of several series that compare relative galling characteristics of specific material candidates.

Future programs will compare relative galling characteristics of various lubricants, finishes and coatings.

C. A. BOLLFRASS

DEC 4, 1986

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify) TORQUE

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

PROJECT TITLE: ANALYSIS OF BEARING DYNAMICS

Name: J.F. Booker Affiliation: Cornell University

Address: Mech. & Aero. Eng.
Upson Hall, Cornell University
Ithaca, NY 14853
Telephone: (607) 255-3618

General objectives are development of

1. basic understanding of dynamic behavior mechanisms
2. quantitative analyses applicable to design

for fluid film bearings and bearing systems with such real world departures from "ideal" conditions as structural compliance, geometrical irregularity, and evolving cavitation.

Methods of approach are numerical and combine finite element fluid/solid analysis with special numerical methods (e.g., for sparse matrix storage, quadratic programming via linear complementarity, modal analysis, stiff system integration, etc.). Intensive use is made of computational resources. Experimental work is a future possiblity.

Specific projects include novel bearing system design analysis methods for reciprocating and rotating machinery, particularly relevant to advanced engines and squeeze film dampers.

Recent work centers on efficient and interpretable computation of the effects of structural compliance and misalignment on oil film thickness and power loss in engine bearings. Efficiency is an issue because heavy computational demands currently require access to supercomputers, severely limiting portabilty of the resulting "design codes". Interpretability is an issue because of the vast amount of information generated, requiring extensive use of computer graphics/animation.

Future work will seek to include improved two-phase models of dynamic cavitation evolution in the bearing model. Experimental validation may be sought through small scale basic experiments at Cornell and/or cooperation with larger scale applied experiments elsewhere.

Future numerical work is also planned to integrate our "local" bearing model into "global" engine sytem analyses.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Cavitation Erosion of Bearing Materials

Name: Richard R Bowles
Affiliation: Clevite Industries Engine Parts Div.
Address: 17000 St. Clair Ave, Cleveland, Oh. 44110
Telephone: (216) 481-7221

This experimental analysis was initiated to rate the relative cavitation erosion resistance of modern day bearing alloys. The vibratory method was used to induce cavitation erosion in test specimens which were submerged in room temperature tap water. The stationary samples were held in close proximity to a stainless steel vibrating tip. Materials tested include: babbitts, cast copper-lead, sintered copper-lead, aluminum based alloys, and electroplated overlays. Relative erosion resistance was determined from the volume loss of the specimens.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
[✓ 7. Erosion]
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: REPLACEMENT OF CHLORINATED WAX IN METALWORKING APPLICATIONS

Name: Dr. W. T. Brannen (Repr.) **Affiliation:** Industrial
Address: The Elco Corporation, P. O. Box 09168, Cleveland, OH 44109
Telephone: (216) 749-2605

EVALUATE CHEMICALS WHICH CAN REPLACE CHLORINATED PARAFFINS IN DRAWING OILS THAT ARE SAFE TO USE BASED ON HUMAN CONTACT.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Dale H. Breen
Affiliation:
Address: ASME Gear Research Institute
Naperville, IL 60566
Telephone: (312) 355-4200

All work on Tribology is being done as a part of other work. It is applied. It has to do with the contact fatigue durability or lubricated wear properties of gears or simulated gears. Current work involves;

1. materials
2. surface finish
3. lubricant formulations
4. finishing methods.

Real gears or roller specimens are used. This work is ongoing thus a significant data base is being generated.

Our future plans include work with coatings and improving quantitative aspects of predicting gear life.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9 Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
[✓ 18 Noise]
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1 Sliding]
[✓ 2 Rolling]
[✓ 3 Slide/Roll]
[✓ 4 Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2 Velocity]
[✓ 3. Temperature]
4 Environment
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
[✓ 8 Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2 Liquid Lubrication]
3. Gas Lubrication
[✓ 4 Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: An Investigation of Joint Degeneration

Name: Thomas D. Brown, PhD
Affiliation: The University of Iowa
Address: Biomechanics Lab, Orthopaedic Surgery, Iowa Ciy, Iowa 52242
Telephone: 319-335-7528

We plan to study the factors promoting progressive cartilage destruction in animal models of osteoarthrosis in order to understand the pathophysiology of this condition. The effectiveness of these models has been established by previous experimentation. The joint tissues are studied biochemically, metabolically, and biomechanically. Since the pathology of osteoarthrosis involves destruction of the articular cartilage and the remodeling of the bone adjacent to the joints, we must use in vivo preparations. Because osteoarthrosis mainly affects mature, older individuals and its development involves an inter-relationship between a variety of tissues, organ cultures utilizing fetal materials are inapropriate. This study, involving collaborative biochemical, biomechanical, anatomical, pathologic, and clinical analyses of these models, should provide a better understanding of osteoarthrosis with the hope that the process can some day be halted and reversed. We propose utilizing poorly-protected-against repetitive impulse loading of a physiologically reasonable amount to create osteoarthrosis in the right knees of rabbits. The left knee is used as a control. We want to establish the threshold levels at which articular cartilage is mechanically injured, the nature of the load which is most deleterious, and the mechanical factors responsible for progression of the joint deterioration. We will first predict the most deleterious force analytically by finite element analysis and test that hypothesis experimentally. We will also utilize stiffening, caused by remodeling of a local area of subchondral bone overlying an implanted plug just under the knee joint of a sheep to study the relationship of bone stiffening and progressive cartilage deterioration. Finite element analysis reveals that such remodeling achieved does increase the stress in the deep layers of the overlying cartilage. We plan to study this in long- and short-term animals to delineate the progression of changes. Experimental results coupled with an expansion of analytical understanding should help define the important mechanical parameters causing joint deterioration in osteoarthrosis.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
[✓ 6. Other (Please Specify)]
Synovial Fluid

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tribology of Rigid Disk Magnetic Storage Drives

Name: Robert W. Bruce
Affiliation: Alcoa Laboratories
Address: Alcoa Center, PA 15069
Telephone: (412)337-5750

Improve the durability of memory disks and reduce starting friction.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tribology of Manufacturing Processes as Casting, Extrusion, Forging and Wire Drawing

Name: Robert W. Bruce
Affiliation: Alcoa Laboratories
Address: Alcoa Center, PA 15069
Telephone: (412)337-5750

Develop lubricants and tribological process optimization leading to improved product quality.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED: [✓ 1. Friction] [✓ 2. Wear] [✓ 3. Lubrication] [✓ 4. Surface Damage] 5. Failure 6. Fretting 7. Erosion [✓ 8. Adhesion] [✓ 9. Abrasion] 10. Fatigue 11. Load Capacity [✓ 12. Surface Temperature] [✓ 13. Contact Stress] 14. Film Formation 15. Oil Analysis 16. Life [✓ 17. Filtration] 18. Noise 19. Leakage 20. Other (Please Specify)	TYPE OF MOTION: [✓ 1. Sliding] 2. Rolling [✓ 3. Slide/Roll] 4. Impact 5. Reciprocating 6. Oscillating 7. Other (Please Specify)
VARIABLES CONSIDERED: [✓ 1. Load/Pressure] [✓ 2. Velocity] [✓ 3. Temperature] 4. Environment [✓ 5. Dist/Time/Amp] [✓ 6. Geometry] [✓ 7. Finish/Lay] [✓ 8. Composition] 9. Structure [✓ 10. Physical Properties] [✓ 11. Thermal Properties] [✓ 12. Chemical Properties] 13. Other (Please Specify)	LUBRICATION: 1. Unlubricated [✓ 2. Liquid Lubrication] 3. Gas Lubrication 4. Grease Lubrication [✓ 5. Solid Lubrication] 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tribology of the Rolling Process

Name: Robert W. Bruce
Affiliation: Alcoa Laboratories
Address: Alcoa Center, PA 15069
Telephone: (412)337-5750

Develop lubricants and tribological process understanding leading to improvements in product surface quality.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Presidential Young Investigator Award: Estimating the Leakage Through Mechanical Face and Shaft Seals for Design Purposes

Name: Dr. Michael D. Bryant
Affiliation: North Carolina State University
Address: Dept. Mech. & Aero. Eng.
NCSU Raleigh, NC 27695-7910
Telephone: (919) 737-3241

Equations and solutions were formulated that describe the leakage through rotating shaft and face seals. These seals are intended to keep fluids from leaking around moving parts from a region of high pressure to a region of low pressure. An example would be the housing in a turbine engine. Both compressible and incompressible fluids were investigated; multiple terms in the film thickness (seal clearance) expression were also included. These terms include seal misalignment, seal waviness, wear, vibration, seal coning, etc.

The sealing gap or film thickness is first determined as a function of the seal surface topographies, seal stiffnesses, thermal deformations, misalignments, and wear. A specialized form of the Reynold's equation (field equation describing fluid motion within the sealed gap) valid for high shaft rotational speeds is then constructed. A power series solution to the thermally nonlinear problem resulted in a closed form expression for leakage, torque, and lifting force.

Finally, in conjunction with this work Dr. Bryant has designed and will soon build a machine that will test rotating seals operating at extreme conditions (50,000 RPM, 100 psi, 1000 deg. F). Results of these tests will be used to verify the accuracy of the analysis.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Thermal, Thermoelastic, and Dynamic Effects in Electrical Brushes

Name: Dr. Michael D. Bryant
Affiliation: North Carolina State University
Address: Dept. Mech. & Aero. Eng.
NCSU Raleigh, NC 27695-7910
Telephone: (919) 737-3241

Dr. Bryant is analytically investigating wear in monolithic carbon graphite brushes as a function of electrical, thermal, material, and mechanical parameters and properties. Here the goal is better brush design through increased understanding of the complex brush to rotor surface physics.

The electric potential field is first determined for a current flowing from the brush to a slipring through a conducting spot. This field results in Joule heat sources which determine a thermal and thermoelastic field. Thermal deformations on the brush surface give rise to surface deformations, which when pressed flat, determines the contacting pressures between the brush and slipring. These pressures in conjunction with sliding velocities are used to estimate adhesive wear using an appropriate law.

Calculations include all thermal changes in material properties characteristic of carbon graphites. Results show that temperatures within the brush can exceed the melting point of the material; at this point stresses are also high. Together this suggests a possible mechanism for catastrophic brushwear different from the adhesive wear.

The PI also plans to build a rig that would allow observation of the sliding interface between a brush and a rotor.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

SURVEY TO ASSESS THE CURRENT LEVEL OF TRIBOLOGY RESEARCH AND DEVELOPMENT ACTIVITIES IN THE UNITED STATES

Name: Ernest Schwarz
Affiliation: US ARMY TANK-AUTOMOTIV
Address: Attn AMSTA-RGRD
WARREN MI. 48397-5000

Project Title: Development of Tribological System and Advanced High Temperature In-Cylinder Components for Advanced High Temperature Diesel Engines.

Project Objective: Develop insulative materials and tribology system to meet the following anticipated future type military diesel operating conditions and goals:

300 (psi) Brake Mean Effective Pressure
12.0 (BTU/Hp-min) Brake Specific Heat Rejection
1100(^{o}F) Top Ring Reversal (Liner Temperature)
320 (lbs/BHP-hr) Brake Specific Fuel Consumption

Approach: Only the approach for the tribology portion of the work scope will be described here. Tasks include: 1) lubricant bench test screening, 2) wear rig testing, and 3) engine testing.

1. High temperature lubricant screening bench thermal and chemical tests will be conducted. Differential scanning calorimeter (DSC), thermogravimetric (TGA), oxidation/corrosion/deposition tests, and chemical tests of new and used lubricants to determine lubrication products and kinetics will be performed. Additive studies will be made to determine response to acids, to examine depletion kinetics, to analyze effectiveness of lubricants when contacted with cermets or ceramic surfaces, and to study toxicity.

2. Wear ring testing will be conducted with candidate high temperature lubricants and liner/ring candidate couples. Oil consumption deposit, friction and wear measurements will be taken and used oil analyzed.

3. Best candidates will then be tested in a small bore direct injection single cylinder diesel engine modified to operate at specified high temperature conditions. The engine will be tore down at given intervals to observe ring/bore condition and deposit formation. Used oil will also be analyzed. From this last iteration of tests, the best high temperature lubricant and liner/ring wear couples will be specified and delivered for 100 hour demonstration in the high temperature large bore single cylinder diesel demonstrator engine.

Status: Monsanto polyolester, polyphenylether and c-ether lubricants and Montefluous perfluoripolyether lubricants are being compared with Stauffer SDL-1 and Mobil 204 polyolester lubricants in initial studies. High temperature stability studies continue with TGA and DSC tests with the Fomblin Z-15 performing the best so far. The Midwest Research high temperature tribometer is currently being re-fabricated. Expected delivery for the wear rig unit is March 87.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Fundamental Tribological Properties of Oxide Ceramics

Name: Donald H. Buckley
Affiliation: Professor, CWRU
Address: Department of Metallurgy and Materials Science
Case Western Reserve University, Cleveland, Ohio 44106
Telephone: (216) 368-4221

Said:

I just recently took a Faculty position at CWRU, and am currently working on the preparation of a proposal to NSF for a MATERIALS RESEARCH GROUP PROGRAM. It will involve faculty from various departments, including Physics, Chemistry, Chemical Engineering, Mechanical Engineering, as well as Metallurgy and Materials Science. The project goals as I have outlined them will be to conduct a comprehensive tribological characterization of three oxide ceramic systems that have potential structural applications. The method of approach will be to conduct a program in three phases. The first phase will involve the measurement of adhesion, friction and wear of the ceramics in contact with themselves and metals to establish baseline data. The surfaces will be well characterized and detailed surface and surficial structural analysis will be performed after tribological experiments. The second phase of the program will involve surface modification of these same ceramics, including ion implantation, ion plating and the deposition of diamond-like carbon films. Again, complete characterization will be performed using analytical tools. The third and last phase will consist of examing the three same ceramic systems lubricated by liquids and solids. The liquids will consist of high purity base stocks and both boundary and EHL lubrication will be examined.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
[✓ 7. Erosion]
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
11. Load Capacity
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: GALLIUM ALLOYS TO LUBRICATE HIGH CURRENT CURRENT COLLECTORS

Name: R. A. BURTON
Address: P.O. Bx 33809
Telephone: RALEIGH NC 27606-0809
Affiliation: BURTON TECHNOLOGIES INC.

Basic study of gallium alloys in contact zone between oxidized metals with sliding and high current (above 1000 amps/in^2) — 2 year program under ONR.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify) contact resistance

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: MOLYBDENUM-DISULPHIDE MOTOR OIL ADDITIVE FOR INCREASED PERFORMANCE & EFFICIENCY IN INTERNAL COMBUSTION ENGINES.
Name: ACCA TECHNOLOGIES CORP.
Affiliation: ASLE MEMBER
Address: P.O. BOX 1266 ATTLEBORO FALLS, MA 02763
Telephone: 617-699-4655

Current research is being directed towards understanding all benefits of a recent breakthrough in totally suspending & electrostatically charging molybdenum-disulphide in an oil additive for use in motor oils for internal combustion engines. Dynomometer testing results thus far indicate excellent advantage of this additive in providing increased power, reduced fuel consumption and a marked increase in mechanical efficiency. Scanning electron microscopy has been utilized to determine the absence of blow-by products on platinum electrode surfaces. Determination of trace metals in motor oil with and without this additive has been surveyed using Inductively Coupled Argon Plasma Spectroscopy indicating a dramatic decrease in engine wear as indicated by chromium levels.

Further research remains in the areas of diesel engine effects, turbo charger efficiency, thermodynamics of motor oil, viscosity evaluation, plus investigation for optimizing military and aerospace attributes.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
18. Noise
[✓ 19. Leakage]
[✓ 20. Other (Please Specify)] FUEL ECONOMY

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Advanced Diesel Engine Propulsion Technology (ADEPT)

Name: Jere G. Castor
Affiliation: Garrett Turbine Engine Co.
Address: 111 So. 34th St., P.O. Box 5217, Phoenix, AX 85010
Telephone: (602) 231-4282

TASK 3- Lubricant Research & Development

The major effort of this task is to formulate and test lubricants which will meet operational and maintainance requirement of an advanced low heat loss compound cycle engine with top ring reversal temperatures in excess of 800°F and piston velocities up to 3000 ft/min. A key requirement is to be able to operate in the engine environment with a minimum of friction and with a reasonable time between oil changes. To meet the goals a friction coefficient less than 0.20 and radial wear rates less than 20×10^{-6} in/hour are required. New material couples and lubricants will be screened by use of Hohman friction and wear tester, Alcor deposition, and micro-oxidation bench testing. Best candidates will be run on a high speed single cylinder test engine under varied PVT conditions using radionucleieded rings. Results of testing are reported under NASA Contract NAS3-24346.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
[✓ 16. Life]
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)
7. Vapor Phase

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: NONE SPECIFIC

Name: KLAUS L. CAPPEL
Affiliation: WYLE LABORATORIES SCIENTIFIC SERVICES & SYSTEMS GROUP
Address: PO BOX 149, MADISON, AL 35758
Telephone: 205-837-4411 (9d) (4)

I HAVE BEEN ENGAGED FOR SEVERAL YEARS IN THE DEVELOPMENT OF SPECIAL MACHINE COMPONENTS, SPECIFICALLY HYDRAULIC SERVO ACTUATORS, WHICH COMBINE POWER ACTUATION WITH SELF-ALIGNING HYDROSTATIC BEARINGS TO PRODUCE VERY COMPACT DEVICES WHICH EXCEED PERFORMANCE OF CONVENTIONAL DEVICES OF THIS TYPE BY A LARGE MARGIN, IN TERMS OF FREQUENCY RESPONSE (UP TO TWO ORDERS OR MAGNITUDE IN THE CASE OF MULTI-AXIS EXCITATION SYSTEMS OPERATING UP TO 2KHZ).

OTHER DEVICES IN DEVELOPMENT ARE HYDROSTATICALLY LUBRICATED SPHERICAL BEARINGS HAVING CAPACITIES UP TO 100 KIPS (OSCILLATING), AND CONSTANT VELOCITY COUPLINGS WITH TORQUES IN THE RANGE OR TENS OR FOOT KIPS (TO OVERCOME LIMITATIONS OF CONVENTIONAL UNIVERSAL JOINTS (WHICH PRODUCE OSCILLATING VELOCITIES), AND OR CONVENTIONAL COUPLINGS OF THIS KIND WHICH ARE LIMITED TO LOW TORQUE VALUES.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify) Response (Stiffness)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify) Rotating

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Development of Improved Cutting Fluids

Principal investigator: David R. Bell
Name: (Others) D. B. Cox, J. L. Graff Affiliation: Chem-Trend Incorporated
Address: 1445 W. McPherson Park Drive, P. O. Box 860, Howell, MI 48844-0860
Telephone: (517) 546-4520

PROJECT GOALS: Currently, the objective is to provide synthetic cutting fluids capable of providing improved surface finish, decreased cutting torque, and improved tool life on cast aluminum parts.

METHOD OF APPROACH: Instrumented drilling, tapping, and cutting experiments.

RECENT FINDINGS: Project just starting.

FUTURE: Extension to steels and other metals.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Various Spacecraft Mechanisms

Name: Ronald Christy
Affiliation: TRW
Address: Box 834 Malibu Ca.
Telephone: 2135351384

Design, Development and Testing of Fluid and dry lubricants for various spacecraft mechanisms

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
[✓ 6. Other (Please Specify)] Hard Coatings (TiN)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Lubrication of Ceramics

Name: Alfeo A. Conte, Jr.
Affiliation: Naval Air Development Center
Address: Warminster, PA
18974
Telephone: 215-441-2835

Project Goals: To develop guidelines for the lubrication of ceramic tribomaterials over the temperature range extending from ambient to 1000 C.

Approach: The response of various ceramic materials to both liquid and solid lubrication will be investigated using frictional data and wear scar analysis.

Recent Findings: New Program

Future Directions: Advance bearing design programs for selection of optimum lubricant systems.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and f

PROJECT TITLE: Molecular Alteration

Name: Alfeo A. Conte, Jr.
Affiliation: Naval Air Development Center
Address: Warminster, PA
18974
Telephone: 215-441-2835

Project Goals: To explore the development of advanced aircraft materials based on the use of intercalated layer-structured solids and deuterium substituted materials.

Approach: Solid film lubricant formulations based on intercalated graphite will be developed using a statistically designed experimental approach. Bearing wear life correlation tests will be performed on deuterated and non-deuterated greases.

Recent Findings: Transition metal chloride intercalated graphite found to possess better wear life than MoS2 and also comparable load carrying ability. Deuterated greases capable of operating at 50 F higher temperature than non-deuterated greases. Bearing performance life at least doubled.

Future Directions: Corrosion inhibition required for solid intercalated solid film lubricant. Additional prototype testing of deuterated greases prior to specification preparation.

PROCESS OR PHENOMENON BEING STUDIED

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

Effects of Manufacturing Process Variables on Surface Topography and Tribological Functionality

J.D. Cogdell
Mech. Engr. Dept.
Rensselaer Polytechnic Inst.
Troy, NY 12180-3590

grad. student: RPI
empl: Caterpillar Inc.

(518) 266-6014

The research proposed herein deals with development of surface topography parameters which will correlate both with manufacturing process parameters of the surface-generating process, and with measures of tribological functionality of the generated surfaces. The primary utility of such parameters is in control of the manufacturing process.

Load-bearing components in machinery usually consist of two surfaces in sliding contact, for example two gear teeth, piston ring/cylinder wall, journal/bearing, ball bearing ball/race, etc. The functionality of such components can be characterized in terms of scuff-limited load-carrying capacity (scuffing is a mode of catastrophic failure characterized by cold-welding of mating surfaces), and/or by the wear rate of the opposing surface. The first measure is more applicable to heavily-loaded components such as gears and rolling element bearings, the second to journal bearings, where the bearing is typically a softer material like babbitt or plastic.

Substantial productivity increases are possible in the manufacture of, for example, reciprocating engine crankshafts, cylinder liners, and valve train components, by better identification of the relationships between surface topography and tribological functionality. This would make possible improved in-process quality control, which would in turn facilitate use of more-productive manufacturing setups.

Larger increases are potentially available through interactive control of the manufacturing process. Computer- controlled machine tools and control theory are available: adequate control models, strategies and parameters are often not. Surface topography parameters which correlate with both the process variables and functionality can form the basis for improved control strategies.

The objective of the proposed research is development of relationships between manufacturing process variables and tribological functionality through surface topography. Because grinding is the process of choice for manufacturing bearing surfaces, efforts will be concentrated on ground surfaces. Milestones in support of this objective include:

a. Manufacture of cylindrical steel journals, using systematic variation in the grinding parameters, on an industrial grinder instrumented to measure energy and temperature.
b. Measure journal profile data in the axial and circumferential directions.
c. Develop surface topography parameters.
d. Quantify tribological functionality of the journals in terms of:
    1) scuff-limited load capacity in conditions of elastohydrodynamic lubrication,
    2) wear rate of soft bearing material (e.g. high-density polyethylene).
e. Establish correlations between the surface topographyparameters, grinding parameters, and tribological functionality.

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6 Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3 Temperature
4 Environment
5. Dist/Time/Amp
6 Geometry
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1 Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Erosion Testing with Cavitating Water Jets

Name: Andrew F. Conn
Affiliation: Tracor Hydronautics, Inc
Jet Technology
Systems Divisi
Address: 7210 Pindell School Rd
Laurel, MD 20707
Telephone: (301) 776-7454

An on-going effort, to understand the processes whereby erosive water jets, using cavitation, remove material: either cutting into a base substance, or removing one material from another.

From these studies: equipment using erosive jets is designed, built, and sold to users for special applications.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
[✓ 7. Erosion]
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
[✓ 7.] Other (Please Specify)
CAVITATING WATER JET

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Microstructural Effects in Solid-Particle Erosion

Name: Hans Conrad + R. Scattergood Affiliation: North Carolina State University
Address: Materials Engineering Dept. Raleigh, N.C. 27695-7907
Telephone: (919) 737-7443

The objectives of this project are to establish improved solid-particle erosion testing techniques and to evaluate the mechanisms of material removal in the erosion of two-phase alloys containing a hard brittle phase in a ductile matrix.

A new method of measuring the erodent particle velocity by the paddle-wheel method was developed; also the influence of the particle flux and fragmentation on the erosion rate were evaluated. Employing single particle impact studies along with steady-state erosion tests, it was established that a key factor in the erosion of the two-phase alloys is the scaling between the impact damage zone size and the microstructure size. SEM observations of single impact craters and measurement of their volume and geometry were important experimental techniques for reaching this conclusion and for establishing the mechanism of material removal.

The research is being extended to fiber-reinforced composites, MgO-partially stabilized zirconia and hot pressed aluminas. Also, the role of the tangential component of the velocity on lateral cracking in brittle materials is under consideration.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
[✓ 7. Erosion]
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Clark V. Cooper
Address: East Hartford, CT
Telephone: (203) 727-7138

Affiliation: United Technologies Research Center

The abrasive wear behavior of several hard compounds is being investigated in a stylus-on-disc configuration, in which a diamond stylus abrades the rotating disc material of interest. The wear rates are compared to measured fracture toughness values to correlate the two phenomena and to understand material wear mechanisms.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Clark V. Cooper
Address: East Hartford, CT 06108
Telephone: (203) 727-7138

Affiliation: United Technologies Research Cente

The sliding wear of induction-surface-hardened and surface-modified nodular and flake graphite cast irons is being investigated with the goal of understanding active wear mechanisms and the effectiveness of various commercial and laboratory techniques for modifying the surface structure and chemistry to improve wear

---

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Clark V. Cooper
Address: East Hartford, CT 06108
Telephone: (203) 727-7138

Affiliation: United Technologies Research Center

The objective of this program is to investigate the wear behavior and mechanisms of hard face coatings deposited onto Ti-base substrates by PVD and PACVD for sliding wear applications.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Advanced Transmission Research

Name: J. Coy
Address: Lewis Research Center
Telephone: (216) 433-3915
Affiliation: Army/NASA.

Goal is to Advance Helicopter Transmission Technology.

- Reduce Weight by 25%
- Reduce Noise by 10db
- Increase Life to 5000HR MTBR

Elements of Program

- Advanced Gear & Lubrication studies
  - high speed, long life, high temp.
- Analytical Modelling
  - life & reliability, stress, temperature, noise
- Demonstrator Transmissions
  - large & small categories
  - scaling effects to be identified.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: A Mathematical Study of Wear of Self Lubricating Materials

Name: James R. Crane
Address: P.O. Box 3707 M/S 73-43 Seattle, WA 98124
Telephone: (206) 237-8241

Affiliation: American Society of Lubrication Engineers
American Chemical Society

This study analyzes changes in wear rate of solid lubricants as a function of the time of wear, slide velocity, and bearing load at constant ambient temperatures. Analysis of nearly 1700 data points dealing with 17 different materials from twenty different experiments using one of four different experimental setups was performed. The data was generated in this and other laboratories.

From this study it was observed that during the overall wearing process, the measured wear rate, in most cases, decreased to a minimum value sometime after the initial application of a specific bearing load and slide velocity and thereafter, the wear rate increased indefinitely, even becoming catastrophic tin time. Even under constant load and velocity, minor fluctuations in the wear rate were observed which were taken into account in the mathematical analyses.

Several types of mathematical expressions which could explain the observations were examined. Analyses of the observations involved the use of mathematical models utilizing special numerical methods, detailed statistical analyses and other types of mathematical tests using a sophisticated computer program which was specifically written for this work. In addition, this program selected the most representative equation which best relates the experimentally obtained wear data with the independent variables, slide velocity, bearing load and wear time. This fortran computer program was run on a DEC VAX 11/750 minicomputer. A paper on this work is being written for publication.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
[✓ 5. Dist/Time/Amp]
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Steven Danyluk
Address:
Telephone: 312-996-2437

Affiliation: University of Illinois
at Chicago
CEMM Dept.
P. O. Box 4348
Chicago, IL 60680

The project goal is to develop an understanding of the lubricated abrasion and wear (wafering) characteristics of semiconductor silicon in order to maximize the cutting rate and minimize the surface damage in silicon wafers. The results of this research are critical to semiconductor silicon wafer manufacturers since they must supply damage-free wafers at the lowest cost to large-scale integrated circuit companies.

Microhardness indentation, single and multiple linear scratch tests, and high speed cutting experiments are used as simulation of industrial wafering practice. The silicon temperature, speed of scratching and cutting, fluid properties, and the applied loads are the variables studied.

Recent findings have shown that silicon which is known to be a brittle solid exhibits ductile behavior at low loads, and plasticity can be induced by deformation in ethanol or at relatively low ambient (T = 200°C) temperatures.

The studies of silicon are being extended to other semiconductors such as gallium arsenide and ceramics such as alumina.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20 Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Daniel B. DeBra
Affiliation: STANFORD UNIVERSITY
Address: Aero & Astro, STANFORD, CA 94305
Telephone: (415) 723-3388

Hydraulic Motors & Externally pressurized bearings for precision machine tools. A new family of devices for actuation and control (valves) based on laminar flow for machines used in manufacturing and measuring optical quality parts. ONR research. Motors works well on first attempt – < 0.1 mm δ nonrepeatability.

Fabrication of fused silica rotors (spheres) to < 1 μin. (20 nm) roundness. Starting with 2-4 lap machines. To investigate in parallel the effect of machine characteristics and the effect of 2 lap designs, compliance, intentional misalignment, temperature and other parameters. Current machines give ≈ 10–20 μin. lapping and ~ 1 μin with polishing. Just starting. Previous work at NASA MSFC transfered to us due to retirements. Rotors are for a very precise gyro with which to test General Relativity in a satellite.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)] Lapping & Polishing

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: CONTACT PROBLEMS: PLATES ON FOUNDATIONS

Name: J. P. Dempsey
Address: Potsdam, New York 13676
Telephone: (315) 268-6517/7701
Affiliation: Clarkson University*

Abstract

Contact problems involving plates on foundations are widely encountered in several fields of engineering. Problems arise whenever the foundation can provide only unilateral support to the plate, i.e., the support reaction p (x,y) is either positive or zero. In this kind of problem, both the contact region and the support reaction are unknown. By virtue of the fact that p $(x,y) \geq 0$, the problems are nonlinear. The present method used to solve the problems involving an elastic foundation is to transform the governing differential equations of a plate into integral equations through finite Fourier transforms. The compatibility and equilibrium conditions between the plate and the foundation reduce the contact problem to a solution of one or several coupled integral equations. Results can be obtained by solving these equations numerically. The integral equations may be singular depending on the types of foundation being modeled A large system of linear equations arises in the solution procedure of these integral equations, with each unknown corresponding to a value of contact pressure at one point inside the contact region. Supercomputer resources are being requested because of the sizeable storage requirements and because of the increasing complexity as more realistic foundations are treated.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Wear of Cutting Tools Impregnated by Plasma Ions

Name: Marvin F. DeVries
Affiliation: University of Wisconsin-Madison
Address: 1513 University Ave. Madison, WI 53706
Telephone: 608 262-0921

A new method of plasma ion impregnation of carbide cutting tools is being used in a study to evaluate the impact on cutting tool performance.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
[✓ 7. Other (Please Specify)]
metal cutting - turning.

VARIABLES CONSIDERED:

1. Load/Pressure
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Effects of Ion Implantation on Cavitation Erosion of Cobalt Based Metal/Carbide Systems

Name: Sara Dillich
Address: Dept. of Mech. Eng.
Telephone: 617 793-5224
Affiliation: Worcester Polytechnic Institute
Worcester, Mass. 01609

The goals of this research were to characterize the erosive wear mechanisms in cobalt based metal/carbide composite systems, and to investigate how these mechanisms may be changed by high fluence ion implantation. Cavitation erosion tests have been performed on nonimplanted and Ti implanted (5×10^{17} Ti/cm^2, 190 keV) samples of a cobalt based superalloy and a 6%Co-WC cemented carbide. Surface damage and material loss from the samples were monitored by periodic weight loss measurements and SEM examinations of the test surfaces.

For both materials, implantation resulted in increased erosion resistance due to diminished carbide-matrix debonding and matrix phase erosion. TEM examination of implanted alloy foils found an amorphous matrix phase and recrystallized carbides. A corresponding toughening of the matrix phase and softening of the carbides, may account for the observed increased erosion resistance of the matrix and improved carbide-matrix cohesion in the alloy. The effects of high fluence N implantation on the microstructure and cavitation erosion resistance of the superalloy and cemented carbides are currently being investigated.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify) cavitation erosion

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify) impact due to cavitation in a liquid

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify) ion implantation

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify) immersion in liquid

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Lower Suspension for a High Speed Centrifuge

Name: Franklin T. Dodge
Affiliation: Southwest Research Institute
Address: 6220 Culebra Road San Antonio, Tx 78284
Telephone: 512-522-2306

Project has recently been completed.

This was an analytical and experimental study of a hydrodynamic squeeze film bearing to be used as the lower suspension for a high speed centrifuge (uranium enrichment). The design had to be optemized so that sufficient restraint was provided while the centrifuge was brought up to speed (passing through many criticals) and yet provide a low load at operational speed in order to prevent fatigue. The analysis considered inertia and turbulence in the fluid film.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify) Vibration

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: THE ROLE OF THERMOELASTIC EFFECTS IN THE SCUFFING FAILURE OF ROLLING/SLIDING EHD CONTACTS

Name: Thomas A. Dow
Affiliation: North Carolina State University
Address: Mechanical and Aerospace Engineering, NCSU, Raleigh, NC 27695
Telephone: (919) 737-3024

The objective of the proposed program is to analyze the thermal effects in a rolling/sliding elastohydrodynamic (EHD) contact to determine the extent to which these effects may be used to explain failure by scuffing. Previously developed mathematical and numerical models are to be modified to allow simulation at the heavy loads and large slip conditions normally associated with scuffing failure. A model will be developed to account for the local distortion in the solid surface due to the thermal stresses produced by heating in the contact zone. A thermoelastic instability hypothesis is to be tested by further developing the model for predicting the load and speed boundary between failure and non-failure, and comparing the predictions to experimental measurements. A significant part of the program is to experimentally explore the characteristics of typical scuffing failure.

Sponsor: Office of Naval Research

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Computer simulation of the friction braking

Name: V.V. Dunaevsky
Affiliation: Westinghouse Air Brake Div.
Address: Wilmerding, PA 15148
Telephone: 412-825-1437

Mathematical model and several computer programs have been developed (in addition to the former WABCO programs) during 1981-1985 to closely simulate surface temperatures and friction/braking parameters of tread/disc braking at various braking procedures including single, multiple, intermittent or drag braking actions.
The analysis is based on wheel/disc design characteristics, braking loads, speed profiles, shoe forces, environmental conditions, properties of friction materials.
Methods of mathematical physics and results of the dynamometer tests were utilized in the technique developed.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Robert Earle
Affiliation: EG&G Rotron
Address: Hasbrouck Lane, Woodstock, N.Y. 12498
Telephone: 914-679-2401

Our company has an ongoing program to investigate new lubricants for blower/fan applications. These applications are somewhat unique in that bearing loads are very low but due to grease type lubrication, lubricant failure is the normal mode of failure. Environments range from -54°C to +125°C and include thermal cycling and full mil-spec exposure.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Dr. Kent J. Eisentraut Affiliation: U. S. Air Force
Address: AFWAL/MLBT Wright-Patterson Air Force Base, Ohio 45433
Telephone: (513) 255-4860

TITLE: SURFACE PHYSICS/CHEMISTRY OF HIGH TEMPERATURE LIQUID LUBRICANTS

APPROACH: Study the interface between metal surfaces and candidate fluid/additive formulations to identify those providing optimal surface film species under conditions of boundary lubrication at high temperature.

Apply surface analysis and fluid analysis techniques to obtain information on the nature of the surface and condition of the bulk fluid. Correlate the data to obtain an understanding of optimum materials interactions which provide the lowest coefficient of friction and reduced wear.

STATUS: This is a new project which is being implemented and no findings have been obtained.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

- [✓ 1 Friction]
- [✓ 2 Wear]
- [✓ 3 Lubrication]
- [✓ 4 Surface Damage]
- [✓ 5 Failure]
- [✓ 6 Fretting]
- [✓ 7 Erosion]
- [✓ 8 Adhesion]
- [✓ 9 Abrasion]
- [✓ 10 Fatigue]
- [✓ 11 Load Capacity]
- [✓ 12 Surface Temperature]
- [✓ 13 Contact Stress]
- [✓ 14 Film Formation]
- [✓ 15 Oil Analysis]
- [✓ 16 Life]
- 17. Filtration
- 18. Noise
- 19. Leakage
- 20. Other (Please Specify)

TYPE OF MOTION:

- [✓ 1 Sliding]
- [✓ 2 Rolling]
- [✓ 3 Slide/Roll]
- 4. Impact
- 5. Reciprocating
- [✓ 6 Oscillating]
- 7. Other (Please Specify)

VARIABLES CONSIDERED:

- [✓ 1 Load/Pressure]
- [✓ 2 Velocity]
- [✓ 3 Temperature]
- [✓ 4 Environment]
- 5. Dist/Time/Amp
- [✓ 6 Geometry]
- 7. Finish/Lay
- [✓ 8 Composition]
- [✓ 9 Structure]
- [✓ 10 Physical Properties]
- [✓ 11 Thermal Properties]
- [✓ 12 Chemical Properties]
- 13. Other (Please Specify)

LUBRICATION:

- [✓ 1 Unlubricated]
- [✓ 2 Liquid Lubrication]
- 3. Gas Lubrication
- 4. Grease Lubrication
- [✓ 5 Solid Lubrication]
- 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: THE EFFECTS OF THIN POLYMERIC SURFACE FILMS IN REDUCING FRETTING CORROSION AND WEAR

Name: N. S. Eiss Jr.* Affiliation: Prof. Mech. Eng.
Address: V.P.I. & S.U., Blacksburg, VA 24061
Telephone: 703-961-7192
* Co-Principal Investigators: H.H. Mabie, M.J. Furey

Project Goals: To determine parameters which influence the duration of protection provided by polymeric films coated on steel substrates when subjected to reciprocating motion. To determine the parameters which will minimize damage to steel when sliding on a polymeric film.

Approach: Experiments in which a spherical surface reciprocates on a flat surface have been run. A wide variety of polymeric coatings have been applied to either the spherical surface or the flat surface. The parameters studied so far include the polymer composition (all single component, i.e. no copolymers or composites), normal load, frequency and amplitude of motion, environment (humidity and air versus nitrogen), and film thickness.

Recent Findings: For all films, an increase in load decreases the life of a film and an increase in film thickness increases film life. For polystyrene, film thicknesses below 30 μm exhibited a power relationship between life L and thickness t which is $L \alpha t^{1.7}$; above 30 μm the relationship is $L \alpha t^{12}$. The thinner films appeared to fail by plastic deformation while the thicker films showed evidence of finely divided debris which may have resulted from fatique wear. The life of polyvinylchloride films is strongly affected by humidity with low humidity giving film lives 15 times greater than high humidity.

Future Directions: The effect of humidity on other polymers will be studied. Surface temperatures will be measured in reciprocating contacts using the infrared microscope.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
[✓ 6. Fretting]
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Peter A. Engel
Address: IBM Endicott Lab
Telephone: 607, 757-1071

Affiliation: IBM Endicott Lab.

① Electrical Connectors

Wear and friction vs geometry and material selection

② Impact wear in Printer Mechanisms

Engineering wear theory for material and geometry selection

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Friction, Wear, and Lubrication of Valve Train Components

Name: Rick Erickson
Affiliation: Norton/TRW Ceramics
Address: 1455 East 185 Street, Cleveland, Ohio, 44110
Telephone: (216) 692-4798

The goal of this program is to develop commercially feasible ceramic components for use in internal combustion engines. Our emphasis will focus on the valve train components of heavily-loaded engines and those engines which are designed to operate under reduced oil lubrication.

Our approach employs laboratory simulations to screen various ceramics for use as valves, valve guides, rocker arm fulcrums, and cam followers. Actual engine tests will then be performed on the most promising ceramic candidates to confirm their applicability.

Now in its fifth month of activity, this program is currently addressing the development of valid laboratory experiments to simulate the wear mechanisms observed in actual engine components.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1 Friction]
[✓ 2 Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11 Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1 Sliding]
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1 Load/Pressure]
[✓ 2 Velocity]
[✓ 3 Temperature]
[✓ 4 Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7 Finish/Lay]
[✓ 8 Composition]
[✓ 9 Structure]
[✓ 10 Physical Properties]
[✓ 11 Thermal Properties]
[✓ 12 Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2 Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Friction, Wear, and Lubrication of Valve Train Components

Name: Rick Erickson
Affiliation: Norton/TRW Ceramics
Address: 1455 East 185 Street, Cleveland, Ohio, 44110
Telephone: (216) 692-4798

The goal of this program is to develop commercially feasible ceramic components for use in internal combustion engines. Our emphasis will focus on the valve train components of heavily-loaded engines and those engines which are designed to operate under reduced oil lubrication.

Our approach employs laboratory simulations to screen various ceramics for use as valves, valve guides, rocker arm fulcrums, and cam followers. Actual engine tests will then be performed on the most promising ceramic candidates to confirm their applicability.

Now in its third month of activity, this program is currently addressing the development of valid laboratory experiments to simulate the wear mechanisms observed in actual engine components.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: HEAD-TO-TAPE INTERFACE (VIDEO TAPE RECORDING

Name: Abe Eshel
Address: MS 3-62
Telephone: 415 367-3084

Affiliation: AMPEX CORP
401 BROADWAY REDWOOD CITY
CA 94063

Measurement of head to tape separation and its dependence on parameters including location on scanner, head geometry, tape characteristics etc. Related analysis and simulation. Externally pressurized guides. Head wear. Dynamics.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

- [✓ 1. Friction]
- [✓ 2. Wear]
- [✓ 3. Lubrication]
- [✓ 4. Surface Damage]
- 5. Failure
- 6. Fretting
- 7. Erosion
- 8. Adhesion
- [✓ 9. Abrasion]
- 10. Fatigue
- [✓ 11. Load Capacity]
- 12. Surface Temperature
- 13. Contact Stress
- [✓ 14. Film Formation]
- 15. Oil Analysis
- 16. Life
- 17. Filtration
- 18. Noise
- 19. Leakage
- 20. Other (Please Specify)

TYPE OF MOTION:

- [✓ 1. Sliding]
- 2. Rolling
- [✓ 3. Slide/Roll]
- [✓ 4. Impact]
- 5. Reciprocating
- [✓ 6. Oscillating]
- 7. Other (Please Specify)

VARIABLES CONSIDERED:

- [✓ 1. Load/Pressure]
- [✓ 2. Velocity]
- 3. Temperature
- [✓ 4. Environment]
- 5. Dist/Time/Amp
- [✓ 6. Geometry]
- 7. Finish/Lay
- 8. Composition
- 9. Structure
- [✓ 10. Physical Properties]
- 11. Thermal Properties
- 12. Chemical Properties
- 13. Other (Please Specify)

LUBRICATION:

- [✓ 1. Unlubricated]
- [✓ 2. Liquid Lubrication]
- [✓ 3. Gas Lubrication]
- 4. Grease Lubrication
- [✓ 5. Solid Lubrication]
- 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Fretting Fatigue Life Prediction Analysis

Name: Prof. Thomas N. Farris Affiliation: Purdue University
Address: Dept. of Aero/Astro, Grissom Hall, West Lafayette, IN 47907
Telephone: (317) 494-5134

Life predictions for mechanical components subject to fretting fatigue are conducted. These will be combined with future fretting experiments at the Northwestern University Center for Engineering Tribology. Recent findings include a detailed surface stress state relevant to fretting fatigue. Future directions include the determination of benefits derived from the use of new engineering materials in fretting fatigue configurations. The effect of surface roughness, lubrication, thermal properties and chemical properties on fretting will also be considered in the future.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: B.C. Felton
Address: PoB 248, Chesterton, IN 46304
Telephone: 219-787-2261

Affiliation: Bethlehem Steel Corp.

Goals: To provide the most cost-effective approach to solving machinery lubrication problems within the steel mills while maintaing a energy or materials conservation approach.

Methods: Primarily field trials based on former laboratory results.

Findings: Synthetic Hydrocarbon lubricants can provide the steel mills with a good lubricant for extreme temperature conditions as well as increased load capacity demands.

Also included is the extended life of sealed work roll bearings utilizing the SHC technology in a grease application.

Future: Documentation of above.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
[✓ 16. Life]
[✓ 17. Filtration]
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

PROJECT TITLE: Tribology of Ceramics

Name: T.E. Fischer
S. Jahanmir
M.P. Anderson
R. Salher

Affiliation: Exxon Res. Eng. Co.
Annandale, NJ
(this is old address)

Basic Research. Pin on disc apparatus. Low sliding speeds for isothermal conditions. Vary the environment and the physical and chemical properties of materials. Dry sliding and model lubricants (H_2O and hydrocarbons).

Findings: chemical interactions of ceramics with environment are important in wear. Oxide ceramics undergo tribochemical reactions; their wear rate decreases 100 fold when humidity is present. Oxide ceramics are subject to stress corrosion cracking; their wear rate increases strongly when humidity is present.

Wear resistance of Zircornia increases with fourth power of toughness.

PROJECT TITLE: Hydrodynamic Lubrication by Liquid Crystals.

Name: T.E. Fischer
S. Bhattacharya
Exxon Res. Eng. Co.

Lubricated sliding represents a very anisotopic flow of liquids. Anisotropy in fluids (such as liquid crystals or fluids composed of large anisotropic molecules) should present interesting new behaivor not predicted by the ories of Newtonian flow.

Experiments with smectic liquid crystal showed strong qualitative departure from classic theory: equivalence of viscosity and velocity/load, which is the basis of the Stribeck curve, does not apply. Hydrodynamic lubrication is extended to much lower velocities. Friction coefficient in hydrodynamic regime is independent of sliding velocity in first approximation.

Future Directions: At Stevens Institute of Technology.
Ceramics: Predominance of brittle fracture and lack of plastic deformation render invalid the traditional theories of wear. Load dependence in particular, is an important consideration since local overload can lead to destruction of bearing.

Thermal effects in high velocity sliding have not been investigated systematically. Early work by Aronov shows the importance of such effect, but is sketchy.

We will investigate dry and lubricated sliding of ceramics under varying loads and velocities, coupling these experiments with theoretical work, we will endeavor the elaboration of a model of friction and wear of ceramics. The main benefit of this model will be to provide designers with guidance on the proper utilisation of ceramics in tribology.

High temperature ceramic tribology.
The chief advantage of ceramics is in high temperature applications. Because of experimental difficulties, little scientific work has yet appeared in the literature. We intend to extend our studies on the mechanical and chemical aspects of ceramic tribology to temperatures up to 1200°C (1500K).

Basic Science of lubrication.
We intend to build on our work with liquid crystals and work towards a theory of hydrodynamic lubrication by fluids with complex molecules. Our approach will be to approximate fluid flow from the high shear end and to make full use of the anisotropy of the situation. (This work will probably occur in collaboration with Professor David Tabor).

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Fluid Film Bearings

Name: Ronald D. Flack, Jr.
Affiliation: University of Virginia
Address: Dept. of Mechanical & Aerospace Engr., Thornton Hall, McCormick Road, Charlottesville, VA 22901 USA
Telephone: (804) 924-6213

The objective of the research is to experimentally evaluate different types of fluid film bearings. Two rigs are used: a flexible rotor and a rigid rotor. The first is to evaluate rotor dynamic/bearing performance including stability and unbalance response. The second is to evaluate strictly the bearing performance. Currently internal pressures, temperatures, film thickness profiles, etc. are measured. The rig is being modified to include dynamic coefficient measurement capabilities. Data is compared to theory for the evaluation of the prediction techniques.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1 Load/Pressure]
2 Velocity
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6 Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2 Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: High Load/Thrust Bearing Damper Test Rig

Name: David P. Fleming
Affiliation: NASA Lewis Research Center
Address: 21000 Brookpark Rd., MS 23-3
Cleveland, OH 44135
Telephone: (216) 433-6013

A test rig has been designed and built to evaluate shaft dampers carrying higher than normal rotating loads combined with steady thrust loads. Dampers to be tested may include fluid film and elastomeric, suitable for high loads (e.g., from blade loss) or for use with thrust bearings of aircraft turbine engines.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)]

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
[✓ 6. Other (Please Specify)]
Elastomer

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Dr. Donald G. Flom
Address: P.O. Box 8, Schenectady, NY 12301
Telephone: (518)387-5938
Affiliation: General Electric Company
Corporate R&D

Project Goals. Reduce the cost of machining by minimizing the need for human involvement in the process. The objectives are to increase manufacturing productivity through more effective machining, to develop new products for the automated factory market, and to increase machined part quality by increased precision in machining.

Approach. Develop and use sensor systems to monitor and control machining processes, capture knowledge in computer systems for automated part programming and for guiding chip control, and develop new cutting tools and systems for precision manufacturing.

Progress. A machine tool monitor for tool touch and tool break detection has been developed and is being applied in manufacturing. Rules for automatic part program generation have been developed for many specific applications. Candidate sensor systems for monitoring of machining center operations are being selected. These sensor systems will be applicable to other tribological systems also. In precision machining, ultra-smooth surfaces are being produced.

Future Direction. In-process sensor systems for monitoring tool wear, workpiece dimensions and surface finish will be developed along with methods for using these data to control the machining process.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: O.I. FORD, Ph.D. Affiliation: THE GENERAL ELECTRIC CO.
Address: MC 750; 175 CURTNER AVE., SAN JOSE, CA. 95125
Telephone: 408 925 1836

PROJECT GOALS ARE TO OBTAIN KNOWLEDGE OF THE CAUSE AND EFFECT RELATIONSHIP BETWEEN PHYSICAL AND CHEMICAL VARIABLES AND THE FRICTION AND WEAR OF MACHINE AND MECHANISM MEMBERS IN RUBBING CONTACT.

METHODS OF APPROACH HAVE VARIED AND HAVE INCLUDED SIMULATION OF ACTUAL MACHINES OF VARIOUS TYPES AND EXPLORING WAYS TO ACCELLERATE THE RESULTS WITHOUT CHANGING THE CAUSE/EFFECT RELATIONSHIPS.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED: [✓ 1. Friction] [✓ 2. Wear] 3. Lubrication [✓ 4. Surface Damage] [✓ 5. Failure] [✓ 6. Fretting] [✓ 7. Erosion] [✓ 8. Adhesion] [✓ 9. Abrasion] [✓ 10. Fatigue] [✓ 11. Load Capacity] 12. Surface Temperature [✓ 13. Contact Stress] 14. Film Formation 15. Oil Analysis [✓ 16. Life] 17. Filtration 18. Noise 19. Leakage 20. Other (Please Specify)	TYPE OF MOTION: [✓ 1. Sliding] 2. Rolling 3. Slide/Roll 4. Impact 5. Reciprocating [✓ 6. Oscillating] 7. Other (Please Specify)
VARIABLES CONSIDERED: [✓ 1. Load/Pressure] [✓ 2. Velocity] [✓ 3. Temperature] [✓ 4. Environment] [✓ 5. Dist/Time/Amp] [✓ 6. Geometry] [✓ 7. Finish/Lay] [✓ 8. Composition] [✓ 9. Structure] [✓ 10. Physical Properties] [✓ 11. Thermal Properties] [✓ 12. Chemical Properties] 13. Other (Please Specify)	LUBRICATION: [✓ 1. Unlubricated] [✓ 2. Liquid Lubrication] 3. Gas Lubrication 4. Grease Lubrication 5. Solid Lubrication 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Low Lambda and high stress in rolling bearings.

Name: Robert Frayer
Affiliation: NTN-Bower.
Address: 3980 Research Pk. Dr. Ann Arbor, Mi 48108
Telephone: 313-761-3613.

Project Goal.— Quantify the effect of Low Lambda, < 0.6, and high stress, > 400,000 psi, on the fatigue life of roller bearings.

Proj. Plan.— Test combinations of lambdas and stress levels, ~~① 0.03λ/600,000 psi, ②~~
λ's of 0.03, 0.1, 0.3, 0.6, 1.2 and
σ's of 600 kpsi, 500, 450, 300.

Status.— 1500 bearings have been characterized and are ready for test. First Tests have started and completion of first phase and interim report will be December of 1987.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: ENERGY REDUCTION IN MECHANICAL PULPING PROCESSES

Name: W. C. FRAZIER
Affiliation: ASME - BOISE CASCADE RESEARCH
Address: 4435 N. CHANNEL AVE, PORTLAND OR 97217
Telephone: 503-286-7408

LARGE SCALE CHIP REFINERS (10,000HP+) ARE USED TO PRODUCE PULP FOR NEWSPRINT. AT LEAST 95% OF THE ENERGY IS DISSIPATED AS WASTE HEAT ALTHOUGH SOME RECOVERY IS POSSIBLE. THE REFINER RESEMBLES A LARGE THRUST BEARING WHEREIN THE WOOD PULP IS A SOLID LUBRICANT. USING FUNDAMENTAL BEARING THEORY I CAN SHOW A GOOD FIT WITH EXPERIMENTAL DATA. THE NEXT STEP IS TO DESIGN THE "BEARING" SURFACES TO IMPART ENERGY TO THE WOOD PARTICLES IN A MORE EFFICIENT MANNER. EVEN A FEW PERCENT IMPROVEMENT COULD SAVE HUNDREDS OF MILLIONS OF DOLLARS P.A. ACROSS THE INDUSTRY.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: FUNDAMENTAL STUDIES ON THE EFFECTS OF THIN POLYMERIC SURFACE FILMS IN REDUCING FRETTING CORROSION AND WEAR

Name: Dr. M. J. Furey
Address:
Telephone: (703) 961-7193
Affiliation: Dept. of Mechanical Engineering
Virginia Polytechnic Institute
and State University
Blacksburg, VA 24061

This research, funded by the U. S. Army Research Office, consists of a systematic investigation of the effects of thin polymeric surface films on fretting corrosion with steel-on-steel systems. The primary goal is to attempt to understand the mechanisms by which such films can protect the surfaces from damage. To do this, a system has been developed and used for experimental studies of fretting corrosion under a wide range of conditions (e.g., load, frequency, amplitude, environment). Under high contact stresses (ball-on-flat geometry), fretting corrosion of steel in air occurs very rapidly; it is a severe tribological process. The use of thin polymeric coatings on steel can greatly delay or completely prevent the onset of fretting corrosion. Over 20 types of polymers have been studied to date. The range in effectiveness is enormous and each polymer seems to exhibit its own characteristic behavior. To be effective, a polymer coating must be "durable" (have long life) and in addition not cause or permit fretting corrosion to occur at the polymer/steel interface. In a five-factor, two-level designed experiment, it was found that load, frequency, amplitude, film thickness, and relative humidity all had significant effects, with several significant interactions existing. All the results taken together show the severity and complexity of the process, demonstrating the importance of both (a) physical/mechanical behavior and (b) chemical effects under fretting conditions. There are several surprises and unexpected findings. In future research in this area, we would like (if additional funding is obtained) to (a) model the physical/chemical processes which can occur with thin layers of polymers on steel substrates, (b) explore the use of in situ polymerization as a replenishment mechanism, and (c) couple this research with an IR system for surface temperature measurements. Our ultimate goal is to understand the tribological processes well enough so that fretting and fretting corrosion in real-world systems can be prevented or minimized. Associate investigators in this research are Drs. N. S. Eiss and H. H. Mabie.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify) POLYMER FILM DEGRADATION CORROSION

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify) POLYMER FILM THICKNESS

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify) POLYMER FILM; HUMIDITY EFFECTS

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: INFRARED MEASUREMENTS OF SURFACE TEMPERATURES PRODUCED BY FRICTION IN TRIBOLOGICAL PROCESSES

Name: Dr. M. J. Furey
Address:
Telephone: (703) 961-7193
Affiliation: Dept. of Mechanical Engineering
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061

Our research on this topic, which began in 1973--supported initially by the U.S. Army Research Office--was later continued with support from the National Science Foundation. The primary goals of this research were (1) to develop a system and experimental techniques which would permit the accurate measurement of surface temperatures during sliding contact, (2) to use this system to determine the surface temperatures produced by sliding various well-defined solids (e.g., pure polymers, graphite, pure metals, etc.) against sapphire, and (3) to compare the experimental results obtained with existing surface temperature theory.

A sophisticated but flexible system built around the use of an infrared microscope was developed and used extensively in this research. The geometry consists basically of a fixed specimen loaded against a thin rotating disc transparent to IR radiation--in this case, a sapphire optical flat. The accurate determination of surface temperatures from infrared measurements is a difficult and complex task; over 30 possible sources of error were identified. But with care and ingenuity, valuable fundamental information can be obtained with this method. As an example, we have been able to measure the detailed temperature distribution over tiny regions of single model asperity and Hertzian elastic contact in well-characterized, dry sliding systems. In addition, a data acquisition/computer system has been coupled to the IR device for faster and better treatment of radiance, emissivity, friction, etc. for analysis. The most important unknown in comparing surface temperature theory and experiment is the real area of contact. Future directions of this research (if funding is available) will emphasize thermal/chemical effects (e.g., degradation of antiwear compounds, tribopolymerization, decomposition) in the contact zone, using this IR system and various surface analytical techniques to study tribochemical surface reactions.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify) IR RADIANCE

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify) TRANSFER FILMS

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: BIOTRIBOLOGY: MECHANISMS OF SYNOVIAL JOINT LUBRICATION, WEAR, AND DEGRADATION

Name: Dr. M. J. Furey
Address:
Telephone: (703) 961-7193

Affiliation: Dept. of Mechanical Engineering
Virginia Polytechnic Institute
and State University
Blacksburg, VA 24061

The term "biotribology" could be used to describe biological lubrication processes such as those involved in the action of synovial or movable joints (e.g., human hips and knees). Unfortunately, there is little known about the lubrication of synovial joints. More than two dozen theories have been proposed to explain synovial joint lubrication. Most of these are strictly mechanical or rheological, generally ignoring the complex biochemistry of the system, and usually preoccupied with friction.

The overall goal of this research--which was funded initially by a grant from the Lane Foundation and later from the Mathers Foundation--is to explore possible connections between tribology and the action and possible degeneration (e.g., osteoarthritis) of synovial joints. In a sabbatical study carried out at the Children's Hospital Medical Center, Harvard Medical School, I determined the effects of various synovial fluid constituents on cartilage wear (not friction) in "in vitro" experiments with bovine cartilage. The work was carried out in collaboration with Dr. David Swann of the Shriners' Burns Institute and Harvard Medical School. The results of this study show that the biochemical composition of the test fluid has a significant effect on cartilage wear (determined from biochemical analysis) and on cartilage wear (determied from scanning electron microscopy).

Future directions will hopefully include additional studies of tribological phenomena--chiefly wear and damage--in tests with cartilage-on-cartilage. This could be done in cooperation with the Virginia-Maryland College of Veterinary Medicine located here at VPI&SU. A better understanding of how normal synovial joints function from a tribological point of view could conceivably lead to advances in the prevention and treatment of osteoarthritis, as well as in partial and total joint replacement.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. ~~Oil Analysis~~] FLUID ANALYSIS
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify) BIOCHEMICAL CHANGES

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify) BIOCHEMISTRY

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify) SYNOVIAL FLUID

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: TRIBOPOLYMERIZATION AS A MECHANISM OF BOUNDARY LUBRICATION

Name: Dr. M. J. Furey
Address:
Telephone: (703) 961-7193

Affiliation: Dept. of Mechanical Engineering
Virginia Polytechnic Institute
and State University
Blacksburg, VA 24061

Research is continuing on the concept of the in situ formation of polymeric films as a new mechanism of boundary lubrication as proposed by Furey in 1973. According to this concept, a potential polymer-forming compound (or compounds) is dissolved at low concentrations in a carrier. Due to the high surface temperatures in regions of greatest contact and possibly to the added catalytic action of freshly exposed surfaces, very thin protective polymeric films will form in these areas--films which continue to be replenished after being worn away. The polymeric films are deposited films, and their basic function is to reduce adhesion, contact, and wear between solids.

This approach to boundary lubrication involves the planned, intentional formation of protective polymeric films and is not to be confused with the vague and unhelpful term "friction polymer" which includes lubricant degradation products. The approach has led to the development of several new classes of potent additives for reducing wear, including compounds effective in reducing fuel pump wear in jet aircraft.

During the 1986-87 academic year, Professor Czeslaw Kajdas of the Technical University of Radom in Poland, is Visiting Professor in our department and working with me in the area of tribology--more particularly, on the chemistry of boundary lubrication. Dr. Kajdas and his group at Radom have also been carrying out research on tribopolymerization in recent years--with some evidence of effects of electrical phenomena (e.g., electron and ion emission) on the polymerization process. We intend to pursue these ideas in more detail to learn more about the tribopolymerization processes--testing our hypotheses and coupling experimental work using our infrared microscope system and surface analytical techniques to examine the structure of this polymer films. This research is not funded at the present time.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify) POLYMER FILM STRUCTURE

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
10. Physical Properties
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: White Etching Areas on surface-hardened gear teeth

Name: John Gamel
Address: 94 Fieldstone Rd, Levittown, PA 19056
Telephone: (215) 945-0616

Affiliation: Naval Ship Systems Engineering Stati
Code 032C
Phila., PA 19112-5083
(215) 897-7318

I am involved with gears and their lubrication for the U.S. Navy. One goal is the introduction of surface-hardened and ground gears into the U.S. Naval fleet. However, proper lubrication of gears and couplings have always been a concern of ours. Scoring studies would be of interest to us along with anti-foaming agents for oils. Current lubrication studies are performed under outside contracts with very little in-house lubrication studies.

The above "Project Title" is a study conducted by John Gamel and The Research Center for Gears at the Technical University of Munich, Germany. The study concerns gear teeth surface damage due to pitting. Pitting is not thought of as a lubrication problem but more so due to over loading and improper gear geometry. However oils with Extreme Pressure addatives could delay the development of small pores in the tooth root areas of gear teeth.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. [✓ Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. [✓ Load Capacity]
12. [✓ Surface Temperature]
13. [✓ Contact Stress]
14. Film Formation
15. [✓ Oil Analysis]
16. Life
17. Filtration
18. [✓ Noise]
19. [✓ Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. [✓ Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. [✓ Temperature]
4. Environment
5. Dist/Time/Amp
6. [✓ Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. [✓ Unlubricated]
2. [✓ Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: TRIBOLOGICAL FUNDAMENTALS OF SOLID LUBRICATED CERAMICS

Name: MICHAEL N. GARDOS
Address: SAME AS BEFORE
Telephone: (213)616-9890

Affiliation: HUGHES

See attached copies.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

- [✓ 1 Friction]
- [✓ 2 Wear]
- [✓ 3 Lubrication]
- [✓ 4 Surface Damage]
- 5. Failure
- 6. Fretting
- 7. Erosion
- [✓ 8 Adhesion]
- [✓ 9 Abrasion]
- [✓ 10 Fatigue]
- [✓ 11 Load Capacity]
- [✓ 12 Surface Temperature]
- [✓ 13 Contact Stress]
- [✓ 14 Film Formation]
- 15. Oil Analysis
- 16. Life
- 17. Filtration
- 18. Noise
- 19. Leakage
- 20 Other (Please Specify)

TYPE OF MOTION:

- [✓ 1 Sliding]
- [✓ 2 Rolling]
- [✓ 3 Slide/Roll]
- 4 Impact
- 5. Reciprocating
- [✓ 6 Oscillating]
- 7. Other (Please Specify)
  UNIDIRECTIONAL

VARIABLES CONSIDERED:

- [✓ 1 Load/Pressure]
- [✓ 2 Velocity]
- [✓ 3 Temperature]
- [✓ 4 Environment]
- [✓ 8 Composition]
- [✓ 9 Structure]
- [✓ 10 Physical Properties]
- [✓ 11 Thermal Properties]

LUBRICATION:

- 1. Unlubricated
- 2. Liquid Lubrication
- 3. Gas Lubrication
- 4. Grease Lubrication

FOREWORD

This 36-month interdisciplinary program is involved with the investigation of microscopic, macroscopic and continuum phenomena which occur between bare and solid lubricated ceramic surfaces under a wide variety of triboenvironmental conditions. The title of the program is "Determination of Tribological Fundamentals", DARPA Order No. 5177, AFWAL Contract No. F33615-85-C-5087. The start date was 09 September 1985, and this volume constitutes the Second Semiannual Report on the program, covering the period of 01 May 1986 to 31 October 1986.

There are three main program objectives:

1. Define the fundamental principles through which the friction and wear mechanisms of environmentally stressed, bare and solid lubricated ceramics can be elucidated.

2. Modify the solid lubricated tribosystems based on the understanding of fundamental principles to attain controlled friction and wear responses under given thermomechanical and atmospheric conditions; and

3. Advance the technology base so that engineers can successfully and confidentially begin to design, build and operate solid lubricated ceramic machine components for extreme environments.

Although the third of these objectives is the driver, this basic materials science program mainly involves (a) atomic (microscopic) modeling and testing of ceramic/solid lubricant interface bonding effects; (b) elucidating the macroscopic thermodynamics of both the solid lubricant films and the ceramic substrates: and (c) determining the tangential shear behavior of ceramic tribosystems in the microscopic, macroscopic and continuum mechanical regimes by specially developed friction and wear test methods and tribometers.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Lubrication/Tribochemistry of Silicon Nitride [illegible] Project

Name: Richard Gates
Affiliation:
Address: NIST, Gaithersburg, MD 20899
Telephone: (301) 975-3677

What will lubricate Silicon Nitride

Effective Additives, chemistry behind them,

Various surface and lubricant analytical techniques will be used as well as bench friction and wear tests to determine performance.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

- [✓ 1. Friction]
- [✓ 2. Wear]
- [✓ 3. Lubrication]
- [✓ 4. Surface Damage]
- 5. Failure
- 6. Fretting
- 7. Erosion
- [✓ 8. Adhesion]
- [✓ 9. Abrasion]
- 10. Fatigue
- [✓ 11. Load Capacity]
- [✓ 12. Surface Temperature]
- [✓ 13. Contact Stress]
- [✓ 14. Film Formation]
- [✓ 15. Oil Analysis]
- 16. Life
- 17. Filtration
- 18. Noise
- 19. Leakage
- [✓ 20. Other (Please Specify)] Brittle Fracture
  Wear Debris Analysis

TYPE OF MOTION:

- [✓ 1. Sliding]
- 2. Rolling
- 3. Slide/Roll
- 4. Impact
- 5. Reciprocating
- 6. Oscillating
- 7. Other (Please Specify)

VARIABLES CONSIDERED:

- [✓ 1. Load/Pressure]
- [✓ 2. Velocity]
- [✓ 3. Temperature]
- [✓ 4. Environment]
- [✓ 5. Dist/Time/Amp]
- [✓ 6. Geometry]
- [✓ 7. Finish/Lay]
- [✓ 8. Composition]
- [✓ 9. Structure]
- [✓ 10. Physical Properties]
- [✓ 11. Thermal Properties]
- [✓ 12. Chemical Properties]
- [✓ 13. Other (Please Specify)] microstructure

LUBRICATION:

- [✓ 1. Unlubricated]
- [✓ 2. Liquid Lubrication]
- 3. Gas Lubrication
- 4. Grease Lubrication
- [✓ 5. Solid Lubrication]
- 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Bearing Performance Life Vs. Synthetic Grease Lubricants.

Name: John Gates
Affiliation: Aerospace Lubricants, Inc
Address: 1505 Delashmut Ave, Columbus, Oh. 43212
Telephone: 614-291-3045

We are using ASTM D3336 to determine effect of temperature and load on the performance life of a variety of synthetic lubricants which we manufacture. Temperature Range 250F to 450F. Loads: 5 lb to 100 lb axial. Synthetics include polyol esters, polyalpha olefins, fluorinated polysiloxanes, fluorinated polyethers. We have recently doubled the bearing performance life at 350F, from about 525 hrs to 1100 hrs under a 70 lb axial load, R-4, Abec 3 test bearing at 10,000 rpm.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: P. R. Ryason
Affiliation: Chevron Research Company
Address: 576 Standard Ave., Richmond CA 94802
Telephone: (415) 620-4927

Tribology at Chevron Research has two parts. One part is concerned with friction, wear, and lubrication in support of product development. The other part is failure analysis, in which the types of wear leading to failure are identified.

Pin on disk tribometers are used in the fundamental studies. Friction and wear measurements are made under a variety of conditions, including controlled environments. Surface analyses, utilizing modern techniques, are an integral part of these studies. Of special interest are inferences as to the surface chemistry of lubricant additives under tribological conditions. Bench tests are sometimes designed and run in support of product development.

Modern microscopic and surface analytical techniques are also used in the failure analysis portion of this effort.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
[✓ 7. Erosion]
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: INTERDISCIPLINARY RESEARCH ON THE FUNDAMENTALS OF SLIDING WEAR

Name: W. A. Glaesar
Address: 505 King Avenue
Telephone: 424-4619
Affiliation: Battelle Memorial Institute

A joint project with Ohio State University Metallurgy Department is being conducted to determine fundamental mechanisms in wear of metals in sliding contact. Battelle is concerned with lubricated wear and Ohio State University is concerned with dry wear. The project goal is to develop models based on material, physical, and mechanical properties to describe the wear process. Recent findings include definition of transfer layers (their similarity with mechanically alloyed systems), evidence of rotation of subgrains during deformation at near surface zone under the wear contact, and the formation of gel structures containing submicron metal particles from surface active lubricants and their deposition on metal surfaces during boundary lubrication.

Future directions include analytical study of microfracture processes involved in high strain deformation. The consideration that fracture of highly strained material involves void formation and growth of cracks at microstructurally significant locations. Analysis also considers comminution of wear debris trapped in the contact area. Preliminary calculations show a minimim size of about 6 mm, close to experimental observation.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1 Friction]
[✓ 2 Wear]
[✓ 3 Lubrication]
[✓ 4 Surface Damage]
[✓ 5 Failure]
6. Fretting
7. Erosion
[✓ 8 Adhesion]
[✓ 9 Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
[✓ 13 Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)
21 NEAR-SURFACE MICROSTRUCTURE
22. TRANSFER

TYPE OF MOTION:

[✓ 1 Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1 Load/Pressure]
[✓ 2 Velocity]
[✓ 3 Temperature]
[✓ 4 Environment]
5 Dist/Time/Amp
[✓ 6 Geometry]
7. Finish/Lay
[✓ 8 Composition]
[✓ 9 Structure]
[✓ 10 Physical Properties]
[✓ 11 Thermal Properties]
[✓ 12 Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1 Unlubricated]
[✓ 2 Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5 Solid Lubrication
6 Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tribo-electrics

Name: Douglas Godfrey
Address: 144 Center St
Telephone: San Rafael CA 94901
(415) 454-9340

Affiliation: San Francisco State University
San Francisco

Determine effect of applied DC currents on friction and wear during boundary lubrication

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Dr. Itzhak Green
Affiliation: Georgia Tech
Address: School of Mechanical Engineering, Georgia Tech, Atlanta, GA 30332
Telephone: (404) 894-6779

Mechanical face seals can be categorized by three basic configurations regarding their dynamic behavior. These categories are (1) the flexibly-mounted stator, (2) the flexibly-mounted rotor, and (3) the flexibly-mounted stator and rotor. While a comprehensive dynamic solution for the flexibly-mounted stator configuration has been recently been completed, the dynamic solution of the other two configurations will be the objective of this program. First, analytical solution of the equations of motion, based on small perturbations which result in linearized stiffness and damping coefficients of the lubricating film, will be obtained. This solution will provide very good insight and useful mathematical expressions for quick prediction and estimation of the seal performance (stability threshold and steady state response). A computer simulation program will then be added to account for nonlinear effects such as cavitation, curvture, and the coupled equations of motion resulting from finite disturbances of the flexibly-mounted seal element(s). A comparison between the analytical solution and the numerical simulation will be made to singling out the range of validity of the analytical solution. This research program will extend our knowledge about the dynamic behavior of two additional and promising seal configurations.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED: 1. Friction 2. Wear [✓ 3. Lubrication] 4. Surface Damage [✓ 5. Failure] 6. Fretting 7. Erosion 8. Adhesion 9. Abrasion 10. Fatigue [✓ 11. Load Capacity] 12. Surface Temperature 13. Contact Stress 14. Film Formation 15. Oil Analysis 16. Life 17. Filtration 18. Noise [✓ 19. Leakage] 20. Other (Please Specify)	TYPE OF MOTION: [✓ 1. Sliding] 2. Rolling 3. Slide/Roll 4. Impact 5. Reciprocating [✓ 6. Oscillating] 7. Other (Please Specify)
VARIABLES CONSIDERED: [✓ 1. Load/Pressure] [✓ 2. Velocity] [✓ 3. Temperature] 4. Environment 5. Dist/Time/Amp [✓ 6. Geometry] 7. Finish/Lay 8. Composition 9. Structure [✓ 10. Physical Properties] [✓ 11. Thermal Properties] 12. Chemical Properties 13. Other (Please Specify)	LUBRICATION: 1. Unlubricated [✓ 2. Liquid Lubrication] [✓ 3. Gas Lubrication] 4. Grease Lubrication 5. Solid Lubrication 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: "Dynamic Analyses of the Flexibly-Mounted Rotor, and the Flexibly-Mounted Stator and Rotor Mechanical Face Seals"

Name: Dr. Itzhak Green Affiliation: Georgia Tech
Address: School of Mechanical Engineering, Atlanta, GA 30332
Telephone: 404-894-6779

Mechanical face seals can be categorized by three basic configurations regarding their dynamic behavior. These categories are (1) the flexibly-mounted stator, (2) the flexibly-mounted rotor, and (3) the flexibly-mounted stator and rotor. While a comprehensive dynamic solution of the other two configurations will be the objective of this program. First, analytical solution of the equations of motion, based on small perturbations which result in linearized stiffness and damping coefficients of the lubricating film, will be obtained. This solution will provide very good insight and useful mathematical expressions for quick prediction and estimation of the seal performance (stability threshold and steady state response). A computer simulation program will then be added to account for nonlinear effects such as cavitation, curvature, and the coupled equations of motion resulting from finite disturbances of the flexibly-mounted seal element(s). A comparison between the analytical solution and the numerical simulation will be made to singling out the range of validity of the analytical solution. This research program will extend our knowledge about the dynamic behavior of two additional and promising seal configurations.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
[✓ 7. Other (Please Specify)]
whirl, wobble

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tribological Evaluation of Materials for Mechanical Seal Contact and Non-Contact Faces

Name: Harold F. Greiner
Affiliation: EG&G Sealol Inc.
Address: 15 Pioneer Avenue, Warwick, R.I. 02888
Telephone: (401) 781-4700

An evaluation of current and potential Seal Face Materials for dry sliding, lubricated contact, and gas lubricated applications. Field of application includes liquified gas, light petroleum products, and dry gas sealing.

Comparison of friction coefficient and frictional heating effects for various combinations of ceramics and carbon-graphite sliding conditions provide basic data for identifying candidates for application testing and further detailed evaluation.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
[✓ 7. Erosion]
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
10. Physical Properties
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: GALLING TESTS

Name: John Groth
Affiliation: FMC Corporation
Address: CEL, 1205 Coleman Ave. Box 580, Santa Clara, CA 95050
Telephone: 408-289-4314

PROJECT GOALS

To rank the threshold galling stresses of material couples.

METHODS of APPROACH

A button on block galling test is used to determine the threshold galling stress of a material couple. A ½"-diameter button is compressively loaded onto a stationary block. The button is rotated by hand 360° and then examined for galling. New buttons are tested at progressively higher loads under threshold galling is observed. A number of material couples and material/coating couples have been ranked (most of the tests results are proprietary).

FUTURE DIRECTIONS

Proposed testing includes threshold galling stress determinations of nitrided cases, electroless nickel coatings, carburized cases chromium plating, synergistic coatings, diffusion alloys and others.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)] Galling

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
[✓ 8. Composition]
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: See Enclosed Project Abstracts

Name: Dr. Pradeep K. Gupta
Affiliation: PKG Inc.
Address: 117 Southbury Road
Telephone: Clifton Park, New York 12065

FRICTIONAL INSTABILITIES IN BALL BEARINGS

ABSTRACT

Computer modeling techniques are used to investigate instabilities in the motions of ball and cage in a ball bearing. As the friction at ball/race and ball/cage contacts increases the cage mass center whirl orbit changes from circular to polygonal and then to a rather erratic shape under excessive friction. The corresponding variations in whirl velocities also increase to represent bearing squeal. It is shown that cage instabilities are directly dependent on the ball/race traction slope, under low slip velocities, and the friction coefficient at the cage interfaces. Under steep traction slopes the variation in traction at higher slip rates are also significant in high-speed bearings. In particular, it is found that a negative traction slope, in the high slip region, may produce appreciable ball skid which promotes excessive interaction in the cage pockets and, perhaps, the most damaging instability of the cage, where the mechanical interactions progressively increase to indicate significant potentials for cage failure. Under stable conditions of operation, the computer results also provide correlations between time-averaged wear rates of the cage and the frictional behavior.

Sponsored by: National Science Foundation Grant Number ISI-8560824

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: See Enclosed Project Abstracts

Name: Dr. Pradeep K. Gupta
Affiliation: PKG Inc.
Address: 117 Southbury Road
Telephone: Clifton Park, New York 12065

OPTIMIZING MANUFACTURING TOLERANCES IN ROLLING BEARINGS FOR CRITICAL DOD APPLICATIONS

ABSTRACT

The influence of manufacturing tolerances in rolling bearings is investigted by parametrically evaluating the dynamic bearing performance, as obtained by the computer program ADORE, as a function of the various imperfections in both ball and roller bearings. Both oil and solid lubricated bearings, typical of high-speed turbine engine application, are considered. The imperfections investigated include, ball size variation, ball unbalance, preferred axis of inertia, race out-of-roundness, variations in race groove curvature and cage unbalance in ball bearings. In cylindrical roller bearings, the bearing performance is modeled as a function of race out-of-roundness, taper in the race and roller surfaces, centrality of flat land on the rollers, roller size variation, roller unbalance and tilt of the inertial axis, and cage unbalance. With prescribed defects in race geometry, the imperfections on the rolling elements are statistically distributed and the bearing performance is correlated to the rms deviation of the imperfections. The bearing performance is evaluated in terms of life, power loss, cage interactions and stability, roller skid and skew instability, guide flange interactions and roller end wear. From the general trend of variation of these performance parameters, practical guidance for obtaining the permissible limits on the various geometrical imperfections is obtained and the general procedure for tolerance optimization for a given bearing under prescribed performance requirements is outlined.

Sponsored by: Aero Propulsion Laboratory
Wright-Patterson Air Force Base
Ohio
Contract Number F33615-84-C-2477

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Ceramic Components for Heavy Duty Diesel Tribological Applications

Name: Nabil S. Hakim
Address: 13400 Outer Drive, West
Detroit, Michigan 48239-4001
Telephone: 595-5625

Affiliation: Detroit Diesel Allison
Division of General Motors Corp.

Assesses the overall worthiness (performance, market-added value, LCC, etc.) of applications of ceramic components to heavy duty diesels.

Also: Other projects which are confidential/proprietary.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Adiabatic Diesel Engine Component Development

Name: Nabil S. Hakim
Address: 13400 Outer Drive, West
Detroit, Michigan 48239-4001
Telephone: 595-5625

Affiliation: Detroit Diesel Allison
Division of General Motors Corp.

- Investigates the proof-of-concept for gas-phase and solid-phase lubrication for the heavy duty low heat rejection engine.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: START/STOP PERFORMANCE FOR ROTATING RIGID DISK MEMORY SYSTEMS

Name: George Hall
Affiliation: Censtor Corporation
Address: 530 Race Street, San Jose, CA 95126
Telephone: 408/298-8400

GOAL: Produce a system having > 20,000 cycles of start and stop with low initial and final friction flying at < 6 microinches.

1) Investigation into variables affecting life of rotating rigid disk memory systems
- (a) Lubricants
  - (1) Solid
  - (2) Liquid
- (b) Slider Design
- (c) Magnetic disk surface properties
- (d) Carbon overcoats

METHODS:

2) Primary investigations are being conducted using start/stop testers designed and built by Censtor. Product is tested using accelerated life testing.

RECENT FINDINGS:

(1) Improved methods for carbon overcoats and surface finishing of disk substrates

(2) Improved slider designs which reduce wear products

FUTURE DIRECTION:

(1) Evaluation of various carbon overcoats in conjunction with lubricants to reduce flying heights of magnetic heads.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
[✓ 7. Erosion]
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Effect of Piston Ring Geometry and Loads on Oil Consumption in a Reciprocating Engine

Name: Henry W. Haslach, Jr.
Address: 8 Frances Court,
Madison, WI 53703
Telephone: 608 - 256 - 7303

Affiliation: College of Engineering
University of Wisconsin
Madison, WI 53706

As a guide to energy conservation, the behavior of a piston ring in a reciprocating engine is computer modeled in order to minimize oil consumption by varying ring geometries and loads. Rather than assume fully flooded conditions, the ring is starved, with inlet and outlet location at each position in the cycle determined by the given parameters such as ring velocity and load.

This work will be extended to include the action of a ring pack. A long range goal is to devise a three dimensional analysis to properly account for the load on the ring and sliding friction.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: FLOW QUANTITIZATION

Name: Robert C. Hendricks
Affiliation: NASA Lewis Research Center
Address: 21000 Brookpard Rd., Cleveland, OH 44135
Telephone: (216) 433-5912

1. Goal is to visualize (qualitative) and vectorize (quantitative) flows in bearings and seals. The project is currently producing data for an eccentric-simulated bearing. Results are being published in London & Hawaii
2. Future direction is to delineate in greater detail the nature and limitations of the system and quantize the limitations of Reynolds equations

PROJECT TITLE: ROTORDYNAMIC INSTABILITIES OF SEALS

1. Goal is to define the rotor dynamic coefficient matrices K, C, M and quantize the nature of the flow fields for arbitrary eccentricity and elliptical precessional orbit.
2. Future direction is to detail the nature of the flow-field at the inlet, within, and exit of the seal system. Papers are published as NASA CP's and BOSTON Conf. + Int-Cryo. Conference in VIENNA.

We also have a program in two-phase flows in seals and bearings — An important area for research. — Publications in ASME J. Lub. & ASLE.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:
1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:
1. Sliding
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:
[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:
1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: "A New Technique to Evaluate Instantaneous Frictional Torque in Reciprocating Combustion Engines"

Name: Naeim A. Henein
Affiliation: Wayne State University
Address: Wayne State Uni. College of Mechanical Engineering, Detroit, MI 48202
Telephone: (313)577-3887, 577-3843

The goal of this project is to develop an innovative method to determine the instantaneous frictional torque in reciprocating combustion engines. While currently known methods determine time averaged frictional torque at constant speed, this new method can determine the time dependant frictional torque under transient conditions as well as under constant-speed operation. This method is known as the (P-ω) method because it utilizes instantaneous gas pressure P, and instantaneous angular velocity to determine instantaneous frictional torques. The results of our work over the last three years indicate that this method promises to be a very effective tool for researchers and engineers working in the areas of fuel economy, tribiology and friction in combustion engines. Our work has been limited to the determination of the instantaneous frictional torque in a single-cylinder diesel engine during cranking and no-load operation. Planned future work includes the development of the method to determine the effects of 1) load and other parameters in a single cylinder engine, 2) interactions between cylinders in multi-cylinder engines. A mathematical model and a computer program will be developed to determine the instantaneous friction from P and ω, for any engine configuration (in line or V-shaped) and for any number of cylinders.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: In-Situ Liquid Lubricated Sliding Studies in the SEM

Name: Wolfgang Holzhauer
Address: M.E. Dept., RPI, Troy, NY 12180
Telephone: (518) 266-6977
Affiliation: Research Assistant
Tribology Laboratory

Modifications to a Scanning Electron Microscope (SEM) allow in-situ sliding experiments to be performed with hydrocarbon liquid lubrication*. This approach is being combined with other analysis techniques such as surface topography measurement and optical microscopy, to gain a better fundamental understanding of the wear mechanisms of low speed boundary lubricated steel contacts.

Recent findings have shown that plastic deformation plays an important part in the deformation and wear of these contacts. A plastically deformed surface layer covers many of the grooves and scratches associated with the original surface finish of the sliding components, thereby displacing beneficial oil from these potential lubricant reservoirs. A plastically extruded layer also covers the surface in two bands along either side of plowing marks which are observed when the wear becomes more severe. This plastically extruded layer is the source of wear debris in the form of flat platelets.

Further experiments are in progress to generate additional data on: 1) the factors leading to the onset of severe wear; 2) correlation with surface topography measurements; and 3) effect of additives.

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* Holzhauer, W. and Calabrese, S.J., "Modification of SEM for In-Situ Liquid-Lubricated Sliding Studies," ASME/ASLE Tribology Conf., Pittsburgh, PA, Oct.20-22, 1986, ASLE Preprint No. 86-TC-6C-2.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED: [✓ 1. Friction] [✓ 2. Wear] [✓ 3. Lubrication] [✓ 4. Surface Damage] [✓ 5. Failure] 6. Fretting 7. Erosion [✓ 8. Adhesion] [✓ 9. Abrasion] [✓ 10. Fatigue] 11. Load Capacity 12. Surface Temperature [✓ 13. Contact Stress] 14. Film Formation 15. Oil Analysis 16. Life 17. Filtration 18. Noise 19. Leakage 20. Other (Please Specify)	TYPE OF MOTION: [✓ 1. Sliding] 2. Rolling 3. Slide/Roll 4. Impact 5. Reciprocating 6. Oscillating 7. Other (Please Specify)
VARIABLES CONSIDERED: [✓ 1. Load/Pressure] [✓ 2. Velocity] 3. Temperature 4. Environment 5. Dist/Time/Amp 6. Geometry [✓ 7. Finish/Lay] 8. Composition 9. Structure 10. Physical Properties 11. Thermal Properties 12. Chemical Properties 13. Other (Please Specify)	LUBRICATION: [✓ 1. Unlubricated] [✓ 2. Liquid Lubrication] 3. Gas Lubrication 4. Grease Lubrication 5. Solid Lubrication 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: TRIBOLOGICAL SYSTEM FLUIDS PROGRAM

Name: Ing T. Hong
Address: 1724 W. Tyler
Telephone: 405-624-7375

Affiliation: Fluid Power Research Center
Oklahoma State University

The Tribological System Fluids (TSF) Program is a cooperatively sponsored industrial research program for the purpose of providing industry with

- Better understanding of hydraulic, lubrication, and fluid mechanics principles,
- Better component and system design procedures applicable to all types of fluid,
- Better fluid assessment procedures specifically engineered for TSF,
- Better fluid analysis and monitoring methods,
- Better filtration techniques and fluid contamination control,
- Better application-sensitive fluid selection methods, and
- Better fluid property control.

The TSF Program addresses three critical areas of interest to lubrication and hydraulic systems:

- Fluid stability and service life,
- Fluid utilization and selection, and
- Fluid conditioning and reclamation.

Research procedures and results are published in the TSF Journal and presented annually in a research conference.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED: [✓ 1. Friction] [✓ 2. Wear] [✓ 3. Lubrication] 4. Surface Damage [✓ 5. Failure] [✓ 6. Fretting] [✓ 7. Erosion] [✓ 8. Adhesion] [✓ 9. Abrasion] [✓ 10. Fatigue]	 [✓ 11. Load Capacity] 12. Surface Temperature [✓ 13. Contact Stress] 14. Film Formation [✓ 15. Oil Analysis] 16. Life [✓ 17. Filtration] 18. Noise [✓ 19. Leakage] 20. Other (Please Specify)	TYPE OF MOTION: [✓ 1. Sliding] [✓ 2. Rolling] [✓ 3. Slide/Roll] [✓ 4. Impact] [✓ 5. Reciprocating] [✓ 6. Oscillating] 7. Other (Please Specify)
VARIABLES CONSIDERED: [✓ 1. Load/Pressure] 2. Velocity 3. Temperature [✓ 4. Environment] 5. Dist/Time/Amp 6 Geometry [✓ 7. Finish/Lay]	 8. Composition 9. Structure [✓ 10. Physical Properties] 11. Thermal Properties [✓ 12. Chemical Properties] 13. Other (Please Specify)	LUBRICATION: 1. Unlubricated [✓ 2. Liquid Lubrication] 3. Gas Lubrication 4. Grease Lubrication 5. Solid Lubrication 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: HUGH H HOROWITZ Affiliation: EXXON RES + ENG Co
Address: Box 51 LINDEN N.J. 07036
Telephone: (201) 474-2445

① Effect of Non-Newtonian properties of polymer thickened lube oils on hydrodynamic lubrication

② Effect of ionic processes in lubricants affecting corrosive wear and affecting oxidation stability

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Les Horve
Affiliation: CR Industries
Address: 900 N. State, Elgin Ill 60123
Telephone: 312 742 7840 ex 3200

Wear, friction Lubrication of radial Lip elastomeric oil seals -- Studies involve the development of Stribeck curves for various operating conditions, oil seal designs and materials. Objective is to understand the sealing mechanism to aid in improving seal performance.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Piston Ring Lubrication

Name: David P Hoult
Affiliation: MIT
Address: Rm 31-161, MIT
Telephone: 617 253-2174

The Lubrication of piston Rings in reciprocating engines is under study. Recent results include the design of a gas lubricated piston ring, and the measurement of oil film thickness on the piston lands of a running engine, using laser florrescence.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. [✓ Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. [✓ Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. [✓ Load/Pressure]
2. [✓ Velocity]
3. [✓ Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. [✓ Liquid Lubrication]
3. [✓ Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Near Surface Wear Structure - Ceramic Components

Name: C. R. Houska Affiliation: Virginia Polytechnic Institute
Address: Dept. of Mat. Eng., Blacksburg, VA 24061
Telephone: 703-961-5652

A theory based on a statistical model was developed and experimentally verified for the x-ray intensity from samples having a rough surface. Experimental measurements from a ground fully stabilized zirconia (FSZ) sample were examined. This theory is valid for both diffraction and fluorescence signals under both symmetrical and asymmetrical optical geometries.

A technique using two wavelengths was first developed by Garvie etc. to determine the depth gradient of the monoclinic phase in a partially stabilized zirconia (PSZ) sample as it extends from the free surface into deeper substrate material. We extended the depth gradient from the originally proposed step function to include both linear and exponential functions. These forms could be influenced by both stress and temperature rises associated with wear processes.

The wear track and unworn side of a PSZ disk were examined using synchrotron radiation. The X-ray diffraction patterns indicate that the wear process resulted in an increase of the cubic and tetragonal phases. This discovery is in accord with localized surface heating which causes the monoclinic phase to attain temperatures that make it unstable in favor of either the tetragonal or cubic phase.

Significant broadening was observed in the (111) peak profiles of PSZ samples after polishing and grinding. These profiles are treated as intensity bands and fitted with a depth dependent d-spacing function. This establishes a new approach for the determination of near surface strain (or stress) gradients which is nondestructive, quantitative and very suitable for examining near surface wear structures of ceramic components. The asymmetrical optical geometry provides an important feature which has shallower penetration depth and better reveals the structure in the near surface region. Synchrotron radiation provides an advantage as longer wavelengths become available giving low beam penetration.

This research is scheduled to terminate 12/31/86.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: 5

Name: R. P. Hunz
Affiliation:
Address:
Telephone:

New E.P. Additives for oil
" " " " water
" Lubricity " " "
" " " " oil
" Corrosion " " "
" " " " water

Keil Chemical is a major manufacturer of E.P., Lubricity + R.P. additives for the metalworking and Industrial lubrication industries ....

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
[✓ 16. Life]
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
[✓ 4. Impact]
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: TWO PHASE CRYOGENIC SEALS (NASA SPONSORED)

Name: William F. Hughes
Affiliation: Carnegie-Mellon University
Address: Mech. Eng. Dept., Pittsburgh, PA 15213
Telephone: (412) 268-2507

Completed simplified computer model for Face Seals with a discrete boiling interface including effects of centrifugal inertia. Simple program runs quickly and is good for estimating the behavior of face seals under normal low leakage.

A detailed study has been made of the effect of heat transfer effects in face seals and how the boiling occurs when the conduction in the faces and convection in the fluid can have arbitrary values. Studies show how very low leakage seals behave but as the leakage increases (but still within practical limits) the boiling may not occur at a discrete interface but may occur over a finite region.

A somewhat startling, and we think very important, conclusion is that under certain circumstances (where the seals can extract enough heat from the leaking fluid) there exists no steady state solution and a "limit cycle" type of oscillation will occur.

This cycling is due to thermal oscillations which are coupled to the dynamical behavior of the seal and can result in a limit cycle.

Far from being an anomolous situation it appears that this sort of behavior may be quite common and can account for many of the oscillatory and erratic seal dynamics behavior observed in the field.

An experimental program was planned and design work begun on the In-House NASA test rig for basic controlled studies of face seals with two-phase flow.

The main thrust of this work will be a detailed parametric study of the thermally induced limit cycle behavior of face seals. In particular we plan to couple the dynamic response to the thermal transient behavior so that actual dynamic tracking may be achieved and perhaps some overall criteria for stable or unstable operation may be established.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)
CRYOGENIC

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: LUBRICANT ANALYSIS PROGRAM

Name: Victor W. Hughes
Affiliation: Standard OIl
Address: 30701 Carter?? Rd. Solon, Ohio 44139
Telephone: 216-349-1330

The project goals are to systematically evaluate the advantage and disadvantage. of technologies that are currently being utilized to determine machinery condition from used lubricant and grease. Spectroscopic, physical and chemical, and wear particle analysis utilizing ferrographic techniques are being reviewed to determine relative effectiveness. Standardized particles have been developed and will be analyzed by the different techniques.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
[✓ 5. Failure]
[✓ 6. Fretting]
[✓ 7. Erosion]
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
[✓ 4. Impact]
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Contact stresses in mating gear teeth

Name: R. L. Huston
Address: Mechanical and Industrial Engineering
Telephone: 513/475-6131
Affiliation: University of Cincinnati
Cincinnati, Ohio 45221-0072

Point load superposition is being used to determine friction and normal forces and stresses in rolling/sliding gear teeth. The effect of lubricant on these stresses has yet to be determined. The results are expected to be useful in the analysis and design of precision power transmissions and gearing systems. The objectives are the development of stronger, more reliable, longer-lived systems.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Wear of Chrome Plating by Printing Inks.

Name: Lewis K. Ives
Affiliation: National Bureau of Standards
Address: National Bureau of Standards
Bldg. 223, Rm B266
Gaithersburg, MD 20899
Telephone: (301) 975-6013

Project Goals:

- Determine mechanism(s) by which chrome plated printing plates wear.
- Develop laboratory test to rank different coatings in terms of wear by printing inks.
- Develop laboratory test to measure relative abrasivity of different printing inks.

Methods of Approach:

- Worn printing press components are analyzed by means of optical microscopy and scanning electron microscopy.
- Based on conditions in printing press, a laboratory wear test device is designed and constructed.
- Laboratory wear results are compared to service information on wear.

Recent Findings:

- Results have been obtained which indicate which are the most important factors in printing plate wear.

Future Directions:

- Work has been suspended pending renewal of contract.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
[✓ 6. Other (Please Specify)] printing ink

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Mechanisms of Galling and Abrasive Wear

Name: Lewis K. Ives
Affiliation: National Bureau of Standards
Address: National Bureau of Standards, Bldg 223, Rm B266
Telephone: Gaithersburg, MD 20899
(301) 975-6013

Project Goals:
- Develop fundamental understanding of Galling mechanisms.
- Develop laboratory test methods for galling.
- Develop method to measure quantitatively severity of galling damage.
- Obtain data on galling behavior of experimental and commercial metals + alloys under various conditions.

Methods of Approach:

Laboratory tests are conducted on carefully prepared and characterized specimens. Subsequent to testing specimens are analyzed using optical microscopy, electron microscopy, metallography, and profilometry. Results are assessed in terms of damage models.

Recent Findings:

Method for measuring galling damage severity based on topography has been developed. Advances have been made in relating galling behavior to materials properties, microstructure, deformation modes and contact conditions.

Future Directions: Project is scheduled for completion in 1 year.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)] Galling

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: NEW ENGINE PROGRAM

Name: ADISH JAIN
Affiliation: DEERE & CO.
Address: 910 JUANITA AVENUE
Telephone: (319)292-8204

DESIGN, DEVELOP, MANUFACTURE AND MARKET A HIGHLY COST COMPETITIVE NEW ENGINE.

APPROACH- CONCURRENT ENGINEERING.

RESULTS- SIGNIFICANT REDUCTION IN DEVELOPMENT TIME
SIGNIFICANTLY HIGHER PRODUCT VALUE.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
[✓ 16. Life]
[✓ 17. Filtration]
[✓ 18. Noise]
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Mechanism of Wear Particle Formation in Fiber-Reinforced Polymeric Composites.

Name: VINOD JAIN
Address: MECH. ENG. DEPT.
Telephone: UNIV. OF DAYTON
DAYTON, OH 45469

Affiliation: NSF GRANT NO. MEA 81-06582

The tests were conducted using a pin-on-disk machine. Effect of load and counterface, and graphite fibers and powder, ~~was investigated~~, on friction and wear was investigated. Copy of the results is attached. Further work is needed to develop a wear equation.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Dr. J. W. Kannel
Affiliation: Battelle Columbus Division
Address: 505 King Avenue, Columbus, OH 43201
Telephone: (614) 424-4626

CURRENT PROJECT DESCRIPTIONS:

1. Development of self-lubricating cage material for turbopumps for cryogenic applications (LOX).
2. Development of computer controlled ball bearing to achieve run-out of 0.01 µm for critical space systems.
3. Development of design criteria to eliminate galling of spool valves in aircraft hydraulic systems.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Improved Wheelchair Tires

Name: J. J. Kauzlarich
Address: Dept. Mech. Eng.
Telephone: (804)924-6218
Affiliation: Univ. of VA.

Summary: Solid rubber wheelchair tires have high rolling resistance and wear. A theoretical study (1) shows improvements depend on rubber losses and tear strength. Anew tire material with better properties is under investigation.

(1) J. of Rehab. R & D., V22 #3, July 1985, pp 25-41. Kauzlarich & Thacker, "Wheelchair tire rolling resistance and fatigue".

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Development of a Microprocessor-Controlled Erosion-Wear Tester for Rapid Data Collection

Name: John E. Kelley
Affiliation: Wear Technology, Inc.
Address: 15152 Pine S.E. Jefferson, OR 97352
Telephone: (503) 327-2795

The production of an extensive erosion-wear data base for engineering metals, ceramics, coatings, polymers, and composites is inhibited by the time and expense required to perform tests. An automated erosion test unit has been designed to allow testing a single specimen at a number of particle impingement velocities and impingement angles in a very short time. The unit will have the capability to increase data production by at least a factor of 10 over other commonly used methods. Generation of a useful data base of erosion characteristics of hundreds of engineering materials is planned once the equipment is produced. Wear Technology, Inc. will produce the testers for marketing to laboratories and will also produce and publish erosion data bases. Funding for development of the equipment is presently being sought.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
[✓ 7. Erosion]
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
[✓ 13. Other (Please Specify)]
[illegible]

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: U.S.-France Collaborative Research on Polymer Wear

Name: Francis E. Kennedy, Jr.
Address: Thayer School of Engineering
Telephone: (603) 646-2094
Affiliation: Dartmouth College
Hanover NH 03755

ABSTRACT

This grant has enhanced the collaborative aspects of a separately-funded study of polymer wear. It has supported travel by the principal investigator and one graduate student to INSA, Lyon, France to work with French researchers working on a related wear study at INSA. The particular topic of interest is the measurement of surface temperatures in polymer-metal sliding contacts and the determination of the efect of temperatures on tribological behavior.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
[✓ 5. Dist/Time/Amp]
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Friction and Wear of Polymers in Oscillatory Motion

Name: Francis E. Kennedy, Jr.
Affiliation: Dartmouth College, Hanover NH 03755
Address: Thayer School of Engineering
Telephone: (603) 646-2094

ABSTRACT

The objective of this research is to understand the mechanisms of polymer wear in reciprocating motion and the influence of material and operating variables on wear and friction. The project involves the following tasks: 1) experimental study of the effect of surface roughness, load, oscillation amplitude, velocity and temperature on friction, wear and third body formation in oscillatory motion of polyethylene against stainless steel; 2) determination of surface temperatures and near surface temperature gradients in sliding polymer against metal; 3) development of a qualitative model to describe the wear process in oscillatory polymer/metal sliding components, and the effect of temperature on that process.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
6. Geometry
[✓ 7. Finish/Lay]
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Thermomechanical Contact Phenomena and Wear of Sliding Components

Name: Francis E. Kennedy, Jr.
Address: Thayer School of Engineering
Telephone: (603) 646-2094
Affiliation: Dartmouth College
Hanover, NH 03755

ABSTRACT

The objectives of this work have been to gain a better understanding of the wear of wear-resistant seal rings and to determine the solid/solid contact conditions responsible for that wear. Ring-on-ring sliding tests have been run under dry conditions (no sealed fluid) with carbon graphite seal rings sliding against three types of hard seal face materials, metals, monolithic ceramics and metallic materials coated with one of several ceramic coatings. Friction, wear, and contact patch sizes have been monitored in the sliding tests. In the analytical phase of this work, the temperature and stress distributions in the sliding contact region are determined using finite element methods. The influence of coating and substrate properties, as well as coating thickness, on the results and on potential failure mechanisms is being studied.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Corrosion of Aircraft Turbine Engine Bearings

Name: Dr. Paul Kennedy
Address: Warminster, PA
18974
Telephone: 215-441-1567

Affiliation: Naval Air Development Center

Project Goals: To develop electrochemical techniques for determining the mechanism of aircraft turbine bearing corrosion.

Approach: Apply quantitative electrochemical techniques to study corrosion at the air/liquid/solid interface. Modify techniques for oil film systems. Study the effect of various parameters on turbine oil corrosion mechanism.

Recent Findings: Developed reusable quantitative electrochemical corrosion probe which operates under accelerated conditions and continuously monitors corrosion current as a function of time..

Future Directions: Will be used as a research technique to study corrosion mechanisms in lubricating oil systems.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED

1. Friction
2. Wear
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9 Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15 Oil Analysis
16. Life
17. Filtration
18 Noise
19 Leakage
20 Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4 Impact
5 Reciprocating
6. Oscillating
7. Other (Please Specify).
NONE (STATIC)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
[✓ 4. Environment]
5. Dist/Time/Amp
6 Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3 Gas Lubrication
4. Grease Lubrication
5 Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Fretting of Ceramic Tribomaterials

Name: Dr. Paul Kennedy
Affiliation: Naval Air Development Center
Address: Warminster, PA 18974
Telephone: 215-441-1567

Project Goals: To determine tribological mechanisms responsible for the failure of ceramic bearings under fretting conditions.

Approach: Ball-on-flat geometry unique fretting tribometer will be utilized to study the wear characteristics of ceramic and metal combinations at extremely small amplitudes (i.e. 0.05 to 5 micrometers), at loads as high as 20 kg, under a variety if atmospheres and temperatures as high as 750 C.

Recent Findings: Micro-damage on silicon nitride specimens was found to change as a function of applied slip. Evidence for oxidation was found a higher slip amplitudes. Friction of ceramic couples found to be lower than metal couples.

Future Directions: Study the effects of atmosphere and elevated temperature.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED

[✓ 1 Friction]
[✓ 2 Wear]
3 Lubrication
[✓ 4 Surface Damage]
5 Failure
[✓ 6 Fretting]
7 Erosion
[✓ 8 Adhesion]
[✓ 9 Abrasion]
[✓ 10 Fatigue]
11 Load Capacity
12 Surface Temperature
[✓ 13 Contact Stress]
14 Film Formation
15 Oil Analysis
16 Life
17 Filtration
18 Noise
19 Leakage
20 Other (Please Specify)

TYPE OF MOTION:

[✓ 1 Sliding]
[✓ 2 Rolling]
3 Slide/Roll
4 Impact
[✓ 5 Reciprocating]
[✓ 6 Oscillating]
7 Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1 Load/Pressure]
2 Velocity
[✓ 3 Temperature]
[✓ 4 Environment]
[✓ 5 Dist/Time/Amp]
6 Geometry
7 Finish/Lay
8 Composition
[✓ 9 Structure]
[✓ 10 Physical Properties]
11 Thermal Properties
12 Chemical Properties
13 Other (Please Specify)

LUBRICATION:

[✓ 1 Unlubricated]
2 Liquid Lubrication
3 Gas Lubrication
4 Grease Lubrication
5 Solid Lubrication
6 Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: M. K. Keshavan
Affiliation: ASTM G-2
Address: Tungsten Carbide Mfg., Tustin, CA 92681-2007
Telephone: (714) 660-5200

~~1. Understand the~~

① See attached Paper.

Project Goal Characterization of Wear and Erosion of cemented carbides and its relationship to microstructure and mechanical properties.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
[✓ 7. Erosion]
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Bardahl 4-Ball EP Wear Test

Name: A. Kiehn
Affiliation: BMC
Address: 7400 NW 52nd St Seattle 98117
Telephone: 206 - 789 - 2856

Develope Bench test which will discriminate between high & low wear engine oils in 4-Stroke Gasoline Engines.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: PARCHED EHL

Affiliation:

Name:
Address:
Telephone:

E. P. KINGSBURY
C. S. DRAPER LAB.
555 TECH SQ., MS 42
CAMBRIDGE, MA 02139
617 - 258 - 4004

EXPOSITION & EXPLORATION OF THE PARCHED EHL REGIME: IE, LUBRICATION WITHOUT FREE BULK LUBRICANT

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify) TRIBO CHEMISTRY

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: R+O Turbine Oils

Name: T. E. Kiousky **Affiliation:** Standard Oil Co.
Address: 3092 Broadway Ave., Cleveland, OH 44115
Telephone: (216) 441-8153

Attempt to define additive/base oil parameters which determine life of turbine oil. Approach is to use a novel carefully controlled oxidation test to determine service life and factors which influence it.

Findings during initial stage indicate rough correlation with standard tests (D-943).

Future will focus on base oil evaluation.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tribomechanical Interactions at Head-Disk Interfaces

Name: Kyriakos Komvopoulos
Affiliation: Assistant Professor
Address: University of Illinois at Urbana-Champaign, 1206 W. Green St., Urbana, IL 6180
Telephone: (217) 244-1303

The purpose of this research is to investigate on a fundamental basis the prevailing tribomechanisms of head/disk contacts during start-stop conditions (i.e., under conditions which promote mechanical interactions between the surface asperities of the magnetic media) and to provide a scheme for effective lubrication.

The tribological properties of various material compositions and lubricants are studied with a pin-on-disk tribotester. The promising material-lubricant systems are examined in more detail using profilometry, SEM and Auger electron spectroscopy for the identification of the predominant mode of wear and the chemistry of the formed surface friction polymers.

These experimental studies and, in addition, computational work based on FEM will provide useful information for the optimum design of magnetic head and disk surfaces.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1] Friction
[✓ 2] Wear
[✓ 3] Lubrication
[✓ 4] Surface Damage
5. Failure
6. Fretting
7. Erosion
[✓ 8] Adhesion
[✓ 9] Abrasion
[✓ 10] Fatigue
[✓ 11] Load Capacity
[✓ 12] Surface Temperature
[✓ 13] Contact Stress
[✓ 14] Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1] Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1] Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
[✓ 7] Finish/Lay
8. Composition
9. Structure
[✓ 10] Physical Properties
11. Thermal Properties
[✓ 12] Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1] Unlubricated
[✓ 2] Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5] Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tribology in Materials Processing

Name: Kyriakos Komvopoulos
Affiliation: Assistant Professor
Address: University of Illinois at Urbana-Champaign, 1206 W. Green St., Urbana, IL 61801
Telephone: (217) 244-1303

The aim of this project is to provide a basic understanding of the tribological mechanisms operating at the workpiece-tool interface during processing. In particular, analytical studies are in progress to investigate the effect of the interfacial friction on the workpiece surface-finish and the magnitude of the residual stresses in drawing, forming and cutting operations.

Also, the magnitudes of the stresses experienced by the tool and the die surfaces are studied as a function of the interfacial friction and temperature conditions, the cutting (or forming) velocity, the tool (die) geometry, and the work-hardening properties of the work material.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
11. Load Capacity
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)] residual stresses, surface finish

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
8. Composition
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Fatigue Mechanisms in Layered Media

Name: Kyriakos Komvopoulos
Affiliation: Assistant Professor
Address: University of Illinois at Urbana-Champaign, 1206 W. Green St., Urbana, IL 618
Telephone: (217) 244-1303

Finite Element Analysis of half-space media with and without surface layers subjected to normal and tangential surface tractions is conducted. The importance of the layer(s) thickness, magnitude of surface tractions, interfacial adhesion and mechanical properties of the coating and substrate materials are critically examined.

Analytical results for the locus and size of the subsurface plastic zone as a function of the position and magnitude of the surface tractions is examined for each case. Moreover, the effect of a surface or interfacial crack on the stress field below the contact is studied and the stress intensity factor is obtained as a function of the length, size and direction of the crack, the layer thickness, the interfacial friction conditions, the relative mechanical properties of the layer and the substrate (e.g., modulus of elasticity and hardness), the position and magnitude of the surface tractions and the size of the contact-width. Crack closure effects are also investigated.

It is anticipated that these studies will provide the appropriate criteria for the design of layered media with improved fatigue properties in sliding/rolling contact conditions.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: High Temperature Ceramic and Metal/Ceramic Materials

Name: Kyriakos Komvopoulos
Affiliation: Assistant Professor
Address: University of Illinois at Urbana-Champaign, 1206 W. Green St., Urbana, IL 61801
Telephone: (217) 244-1303

The thrust of this research project is on the fundamental friction and wear mechanisms in high temperature sliding and rolling contact conditions. A variety of ceramic materials will be tested in a high temperature apparatus up to 1600 K at different loads and relatively low speeds. The predominant friction and wear mechanisms at each temperature and/or stress range will be analyzed via friction coefficient and wear rate measurements, and be characterized with profilometry, SEM, EDXA and Auger electron spectroscopy.

In a later stage, the tribological properties of ion plated, laser cladded and laser chemical vapor deposited ceramic layers on ceramic and metallic substrates will be studied. Also, part of the research work will be directed to the liquid and solid lubrication aspects for high temperature sliding/rolling applications the emphasis being on in-situ formed lubricating films. The purpose of this research is the design of low friction ($\mu < 0.1$) and high wear resistant surfaces for high-temperature and high nominal contact stress conditions, similar to those in advanced mechanical systems such as the adiabatic diesel engine.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: WEAR MODELLING / LIFE PREDICTION

Name: BRUCE M. KRAMER
Affiliation: GEORGE WASHINGTON UNIV.
Address: PHILLIPS HALL - T715, WASHINGTON, DC 20052
Telephone: (202) 994-8237

THE PROJECT INVOLVES THE THEORETICAL MODELING OF THE WEAR OF CERAMIC COATINGS USING ABRASIVE WEAR THEORY AND DISSOLUTION WEAR THEORY. ABRASIVE WEAR CONTROLS AT LOW TEMPERATURES AND DISSOLUTION WEAR AT HIGH TEMPERATURES. THE MODEL ACCURATELY PREDICTS THE WEAR OF COATED TOOLS IN CUTTING STEEL. FUTURE DIRECTIONS INCLUDE THE MODELING OF THE FRACTURE PROCESS AND EXTENSION TO NON-CUTTING APPLICATIONS.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

- [✓ 1. Friction]
- [✓ 2. Wear]
- 3. Lubrication
- 4. Surface Damage
- [✓ 5. Failure]
- 6. Fretting
- 7. Erosion
- 8. Adhesion
- [✓ 9. Abrasion]
- [✓ 10. Fatigue]
- 11. Load Capacity
- 12. Surface Temperature
- 13. Contact Stress
- 14. Film Formation
- 15. Oil Analysis
- 16. Life
- 17. Filtration
- 18. Noise
- 19. Leakage
- 20. Other (Please Specify)

TYPE OF MOTION:

- [✓ 1. Sliding]
- 2. Rolling
- 3. Slide/Roll
- 4. Impact
- 5. Reciprocating
- 6. Oscillating
- 7. Other (Please Specify)

VARIABLES CONSIDERED:

- [✓ 1. Load/Pressure]
- [✓ 2. Velocity]
- [✓ 3. Temperature]
- 4. Environment
- 5. Dist/Time/Amp
- [✓ 6. Geometry]
- 7. Finish/Lay
- [✓ 8. Composition]
- 9. Structure
- [✓ 10. Physical Properties]
- 11. Thermal Properties
- [✓ 12. Chemical Properties]
- 13. Other (Please Specify)

LUBRICATION:

- [✓ 1. Unlubricated]
- 2. Liquid Lubrication
- 3. Gas Lubrication
- 4. Grease Lubrication
- 5. Solid Lubrication
- 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Studies of Surface Processesand Temperatures During Friction and Wear

Name: D. K.-W. Kuhlmann-Wilsdorf
Affiliation: University of Virginia
Address: Dept. of Physics, Charlottesville, VA 22901
Telephone: (804) 924-6812

Obtain a more detailed insight into the processes occurring at sliding interfaces. Various approaches are used, including theoretical calculations of contact spot temperatures, development of models of friction and wear, optical studies of wear debris and interfaces and, above all, correlated measurements of coefficient of friction and interfacial electrical resistance.

PROJECT TITLE: Development of Metal Fiber Brushes

D. K. - W.

Investigate the behavior of metal fibers for the conduction of electrical currents across sliding interfaces with a view to develop useable metal fiber brushes.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
[✓ 18. Noise] (electrical)
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)
[✓ 8.] Stick-Slip

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: WORM GEARS

Name: NIRMAL KUMAR Affiliation: ASME
Address: EIMCO PEC, PO BOX 300, SLC, UT 84110
Telephone: (801) 526-2297

① BY CHANGING THE MATERIALS AND GEAR GEOMETRY AND LUBRICANT IT WAS EXPERIMENTED AND PROOVED THAT GEARS OF A PARTICULAR SIZE COULD BE RATED FOR TWICE (APPROX) THEIR PREVIOUS RATINGS.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Additive Technology and Used Oil Analysis Can Extend Machine Life

Name: Richard W. Kuster
Affiliation: GC Quality Lubricants, Inc.
Address: 5738 Charles Dr., Macon, GA 31210
Telephone: (912) 477-3999

Diesel Engines

Longer drain intervals conserve lubricants. Safely extended drain intervals from 12,000 miles to 20,000 miles

Higher alkaline reserve oils can extend Diesel engine life.

Diesel engine life improved by a factor of 3

Hydraulic Systems

Used oil analysis can direct hydraulic maintenance. Contaminant removal can extend system life and oil Life. Documented examples of savings in maintenance costs of millions of dollars.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
[✓ 16. Life]
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: WEAR RESISTANT MATERIALS FOR THE MINING AND MINERAL PROCESSING INDUSTRIES.

Name: GEORGE LAIRD II, P.E. Affiliation: ALBANY RESEARCH CENTER
Address: P.O. BOX 70. ALBANY, OR 97321
Telephone: (503) 967-5852

IMPACT AND ABRASION STUDIES ON HIGH AND MEDIUM CHROMIUM WHITE CAST IRONS (30-8% Cr, 3.5-3.0% C).

THESE CAST IRONS ARE KNOWN FOR THEIR SUPERIOR ABRASION RESISTANCE, BUT POOR IMPACT RESISTANCE. THEY HAVE A TWO PHASE MICROSTRUCTURE OF BRITTLE CHROMIUM CARBIDES AND MARTENSITE/AUSTENITE MATRIX, WHICH ADDS A UNIQUE TWIST TO THE ANALYSIS.

GOALS: A) IMPROVE IMPACT RESISTANCE BY MICROSTRUCTUR MODIFICATION.
B) ALLOY DEVELOPMENT – LOWER THE Cr CONTENT WHILE MAINTAINING THE WEAR RESISTANT PROPERTIES.
C) FUNDAMENTALLY UNDERSTAND THE IMPACT AND ABRASION PROCESS.

DRIVING FORCE: DECREASE THE U.S. DEPENDENCE UPON CHROMIUM CONTAINING MATERIALS.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

- [✓ 1. Friction]
- [✓ 2. Wear]
- 3. Lubrication
- [✓ 4. Surface Damage]
- [✓ 5. Failure]
- 6. Fretting
- 7. Erosion
- 8. Adhesion
- [✓ 9. Abrasion]
- 10. Fatigue
- 11. Load Capacity
- 12. Surface Temperature
- [✓ 13. Contact Stress]
- 14. Film Formation
- 15. Oil Analysis
- 16. Life
- 17. Filtration
- 18. Noise
- 19. Leakage
- 20. Other (Please Specify)

TYPE OF MOTION:

- [✓ 1. Sliding]
- 2. Rolling
- 3. Slide/Roll
- [✓ 4. Impact]
- 5. Reciprocating
- 6. Oscillating
- 7. Other (Please Specify)

VARIABLES CONSIDERED:

- [✓ 1. Load/Pressure]
- [✓ 2. Velocity]
- 3. Temperature
- [✓ 4. Environment]
- [✓ 5. Dist/Time/Amp]
- [✓ 6. Geometry]
- 7. Finish/Lay
- [✓ 8. Composition]
- 9. Structure
- [✓ 10. Physical Properties]
- 11. Thermal Properties
- 12. Chemical Properties
- 13. Other (Please Specify)

LUBRICATION:

- [✓ 1. Unlubricated]
- 2. Liquid Lubrication
- 3. Gas Lubrication
- 4. Grease Lubrication
- 5. Solid Lubrication
- 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Cable Materials Abrasion and Corrosion Testing

Name: Jorn Larsen-Basse
Affiliation: Georgia Institute of Technology
Address: Ga Tech, School of Mechanical Engineering, Atlanta, GA 30332
Telephone: (404) 894-6839

A 350 kV submarine power cable is being designed to link the geothermal fields on the island of Hawaii with the population center in Honolulu, some 280 km away. Goals of the present study are to assess the potential of premature failure of this cable due to abrasion against submarine rocks, or due to combinations of abrasion and corrosion. Abrasion is a potential failure mode over part of the route for this cable because of the presence of rock outcroppings from geologically recent eruptions and because of the significant tidal currents at the site.

Initial work on slurry abrasion of various polymers used in cable construction showed that crushed lava can be very abrasive because of the sharp grains formed in the crushing process. Attempts to correlate the results with hardness and fracture toughness of the polymers showed only very qualitative agreement with existing models.

Preliminary slurry abrasion tests of armor wire materials have been combined with corrosion data from the site and with various possible combinations of load and excursion per cycle. These initial estimates of maximum damage show that failure due to abrasion plus corrosion could take place in 5-10 years, well short of the desired design life of 30 years.

Current tests are conducted in cooperation with the University of Hawaii and the Hawaii Natural Energy Laboratory. The abrasion of armor wire (cold drawn AISI 1085 steel) against slices of submarine lava rock is being studied in order to determine wear rate, change in abrasiveness with time, and change in cutting force (and thus in possibl length of excursion per load cycle). Final tests will include corrosion-erosion tests in seawater with removal of corrosion products by sliding wear at a frequency simulating the tidal frequency.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Abrasion Resistance of Tool Materials Related to Microstructure

Name: Jorn Larsen-Basse **Affiliation:** Georgia Institute of Technology
Address: Ga Tech, School of Mechanical Engineering, Atlanta, GA 30332
Telephone: (404)894-6839

Project goals are to determine quantitative relationships between the microstructure, hardness and toughness of hard tool materials and their resistance to abrasive wear.

The approach has been to determine abrasive wear rates at room temperature under two-body or three-body conditions using various abrasives and to correlate the results with hardness, fracture toughness, and microstructural parameters.

Recent work involved abrasion of WC-Co alloys by SiC in three-body testing. Results were evaluated using Zum Gahr's model of abrasion due to combined plastic deformation and brittle surface cracking, and applying K_{Ic} values determined by indentation techniques. It was found that the general concept of the model agrees with the results but that it vastly overestimates the wear due to brittle fracture in WC-Co alloys. For these materials it is also necessary to include a term due to microfracture and removal of WC grains.

Work in progress includes evaluation of abrasion results for some titanium carbonitride cermets and for some sialon materials. For the former group of materials it was found that 85 μm SiC and 1 μm diamond powder abrasives give the same variation in wear rate with composition and both remove material by a combination of plastic indentation and brittle cracking. Quartz abrasives, on the other hand, remove material by local pressure without plastic indentation which results in microfracture on a scale of the material's grains. The wear rate due to abrasion by quartz is significantly affected by the specimen composition and appears to correlate closely with wear rates seen in machining. Additional evaluation of the results is in progress.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Design of a Long Life Submarine Shaft Seal

Affiliation: Sponsor: NAVSEA

Name:
Address:
Telephone:

Alan O Lebeck
Mechanical Engineering
U of NM
Albuquerque, NM 87131
505-277-2761

"Description and Classification of Specific Basic/Applied Research"

The project has been underway for several years with the purpose of performing basic research, design, and development directed toward the design of a new type of submarine shaft seal which would have significantly greater life that the present shaft seals. The work has involved theoretical developments as well as a considerable experimental effort. The principle which has been utilized to extend shaft seal life is to use waviness to enhance lubrication. Small scale experiments have been completed. At the present time, a full scale submarine seal design is being completed.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

Elevated Temperature Sliding Wear of Ceramic Coatings

Name: Alan V. Levy
Address: University of California, Berkeley California 94720
Telephone: (415)486-5822

The sliding wear of ceramic coatings that are suitable for use on the cylinder wall liners of ceramic coated diesel engines is being determined. Coating systems that can provide thermal insulation and have low wear rate and friction coefficient characteristics in unlubricated sliding wear at operating temperatures to 750°C are sought. Coating systems are being procurred from experienced suppliers with controlled variations in composition, morphology and processing and tested using a washer on disc specimen configuration. It has been determined that thermal sprayed chromia has much lower wear rates and coefficient of friction at 400°C than at 25°C because of a glazing mechanism which occurs on the wear surface. Efforts to understand and optimize the glazing action are underway. Other ceramics with potentially similar behavior are being sought. Solid particle erosion of the coatings is also being investigated.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Surface Texture Research

Name: Joel A. Levitt **Affiliation:** Ford Motor Company
Address: E1158 SRL, POB 2053, Dearborn MI 48121
Telephone: 313/323-1609

In coordination with work on adhesive forces, boundary layer lubricant rheology, catalyzed lubricant chemistry, flow in restricted channels, diffusion in strain fields, slow crack growth and fracture, the objective of the surface texture program is to establish the relationship between texture and component function and durability.

To this end, we are developing stylus and (with K.C. Ludema, UM) SEM-based backscattered electron instruments for texture measurement. Work is in progress to represent texture in a way that is appropriate to calculating the expectation value of functions of elevation and its derivatives (to third order). Designed experiments are anticipated to correlate texture with function and durability. Measurements will be used in exploring the connection between texture statistics and optical scattering in the hope of developing an instrument suitable for measurements at production rates and in production environments.

Interferometric sensing of stylus position in the direction of traverse, together with mechanical, thermal and electrical isolation, has led to an instrument that can measure elevation to within 7.5 nm over a linear dynamic range of 38 microns at points located to within 150 nm along a 3 cm line of traverse. Noise reducing Fourier methods can be used to integrate backscattered electron data in order to generate topographic maps of surfaces. It is believed that precise measurements can be made by incorporating fiducial marks in the SEM field of view, which are used to frequently recalibrate the backscattering instrument. So many data are required to develop reliable statistics, that it has come to appear that generating a fourth-order Markoff-process nonparametric probability density function to describe surface texture is impracticable.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13 Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
[✓ 18. Noise]
[✓ 19. Leakage]
20 Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
[✓ 4. Impact]
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED.

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13 Other (Please Specify)

LUBRICATION.

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: FIBROUS WIPING OF (MAGNETIC MEDIA) POLYMERIC SURFACES

Name: ARMAND LEWIS
Address: 95 WEST ST. WALPOLE
MA. 02081
Telephone:

Affiliation: KENDALL COMPANY
RESEARCH DEPARTMENT

UNDERSTAND FUNCTION OF LINER FABRICS IN THE WIPING OF MAGNETIC MEDIA (FLOPPY DISKS). MODEL MECHANISMS OF FIBROUS WIPING OF SOLID SURFACES. DEVELOP OPTIMIZED FABRICS / SYSTEMS FOR OPTIMIZED WIPE FUNCTION.

A. F. Lewis

12-8-86

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

- [✓ 1. Friction]
- [✓ 2. Wear]
- [✓ 3. Lubrication]
- [✓ 4. Surface Damage]
- [✓ 5. Failure]
- [✓ 6. Fretting]
- 7. Erosion
- [✓ 8. Adhesion]
- 9. Abrasion
- 10. Fatigue
- 11. Load Capacity
- [✓ 12. Surface Temperature]
- 13. Contact Stress
- [✓ 14. Film Formation]
- 15. Oil Analysis
- [✓ 16. Life]
- 17. Filtration
- [✓ 18. Noise]
- 19. Leakage
- 20 Other (Please Specify) TRIBO ELECTRICAL EFFECTS

TYPE OF MOTION:

- [✓ 1. Sliding]
- 2. Rolling
- 3. Slide/Roll
- 4. Impact
- 5. Reciprocating
- 6. Oscillating
- 7. Other (Please Specify)

VARIABLES CONSIDERED:

- [✓ 1. Load/Pressure]
- [✓ 2. Velocity]
- [✓ 3. Temperature]
- [✓ 4. Environment]
- [✓ 5. Dist/Time/Amp]
- [✓ 6. Geometry]
- [✓ 7. Finish/Lay]
- [✓ 8. Composition]
- [✓ 9. Structure]
- [✓ 10. Physical Properties]
- [✓ 11. Thermal Properties]
- [✓ 12. Chemical Properties]
- [✓ 13. Other (Please Specify)] ELECTRICAL Properties

LUBRICATION:

- [✓ 1. Unlubricated]
- [✓ 2. Liquid Lubrication]
- 3. Gas Lubrication
- 4. Grease Lubrication
- 5. Solid Lubrication
- 6. Other (Please Specify)

SURVEY TO ASSESS THE CURRENT LEVEL OF TRIBOLOGY RESEARCH AND DEVELOPMENT ACTIVITIES IN THE UNITED STATES

Name: Frances E. Lockwood
Address: P.O. Box 7569
The Woodlands, TX 77387
Telephone Number: 713/363-8022

Affiliation: Pennzoil Products Company

Summary of some of the tribological studies being carried out at Pennzoil Products Company.

1. Liquid Crystals as "Lubricants"

Different types of lamellar liquid crystals are being studied for use as lubricants. Focus is on determination of important parameters controlling their rheological and tribological properties, such as viscoelasticity and load-carrying capability, EHD film thickness, friction reduction and wear reduction, and variation of rheological properties by electric and magnetic fields.

2. Mineral Oil Basestocks

We are investigating the relationship between bulk flow properties and/or chemical structure of mineral oils and their useful temperature range of application, friction and wear modes under specific test conditions, and their oxidative/thermal decomposition tendencies.

3. High Temperature Lubrication

Studies are being undertaken to design high temperature lubricants for low heat rejection engines. The new class of lubricants will be capable of withstanding temperatures of the order of 400-500°C.

4. Ferrography

Wear monitoring of engines and of pumps and compressors through ferrographic analysis of used oil is being conducted. The method consists of "tracking" the variation of wear particle concentration with time. Wear particle concentration and the ratio of large to small particles delineates the wear regime (catastrophic or mild).

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Fundamental Research on Tribology

Name: F.F. Ling and J.L. Lauer Affiliation: Rensselaer Polytechnic Institute
Address: Dept. of Mechanical Eng., Troy, NY 12180-3590
Telephone: (518) 266-6992

Reduction of wear between solid surfaces in relative motion is the global concern of our multifaceted interdisplinary program. Therefore boundary lubrication of metallic and non-metallic (polymeric and ceramic) surfaces is the prime object of study by a variety of approaches and techniques, some of them specially designed or adapted. For example, we have been studying (i) relations between surface texture and wear, friction or failure, using both SEM, stylus and optical profilometry , (ii) surface layers by ellipsometry, AES and other ultrahigh vacuum techniques, and by infrared emission spectroscopy (a special technique developed here), as a function of lubricating oil and additive composition, (iii) transfer films from polymeric components and their relation to friction, (iv) capillary and other interfacial forces at elevated temperatures to relate with lubricant flow, and (v) catalytic reactions of model compounds on surfaces.

Recent findings were methods of generating friction-reducing graphitic carbon by catalytic dissociation of combustion gases at surfaces and at temperatures approaching those prevailing in contacts of low heat-rejection ("adiabatic") diesel engines (a method of solid lubricant replenishment) and relations between failure mode and surface texture.

Future directions are toward new, especially ceramic materials and higher temperatures.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
[✓ 7. Erosion]
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: (1) BEARINGS STUDY
(2) WEAR OF WHEELS AND RAILS

Name: ROBERT. Z. LIN
Affiliation:
Address: 7737 KOSTNER AVE. SKOKIE, IL. 60076
Telephone: (312) 567-6750

(1). REDUCE THE BEARING FRICTION.

(2). WARNING OF BEARING FAILURE.

(3). LENGTHEN THE BEARING LIFE.

(4). PITTING OF BEARING.

(5). REDUCE WHEEL/RAIL WEAR.

(6). LUBRICATION OF WHEEL/RAIL CONTACT.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
11. Load Capacity
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: LUBRICATION OF SPACE MECHANISMS

Name: STUART H. LOEWENTHAL Affiliation: LOCKHEED MISSILES & SPACE Co
Address: 0/62-14 B/551, P.O. BOX 3504, SUNNYVALE CA. 94088
Telephone: ~~F~~ (408) 743-2491

ANALYTICAL INVESTIGATION, SUPPORTED BY BEARING PERFORMANCE TEST DATA, TO IMPROVE PREDICTIVE ACCURACY OF SPACE CRAFT BEARING FRICTIONAL TORQUE signatures IN A VACUUM WITH IMPOSED THERMAL GRADIENTS UNDER VARIOUS SOLID/LIQUID LUBRICANT FILMS.

PREDICTIVE MODEL CURRENTLY SHOWS REASONABLE AGREEMENT WITH TEST DATA AT NOMINAL TEMPERATURE CONDITIONS AT AMBIENT PRESSURES. MODEL NEEDS TO BE EXTENDED TO WIDER TEMPERATURE EXTREMES AND for A VARIETY OF LUBILCATION CONDITIONS. EFFECT OF LUBRICATING FILM DETERIATION WITH TIME NEEDS TO BE INCORPORATED, SUCH AS VAPOR PRESSURE VS. TIME ~~VS.~~ EVAPORATION EFFECTS.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: The Role of Surface Topography and Condition on Wear and Scuffing Behavior

Name: K C Ludema
Affiliation: Univ of Michigan
Address: ME / AM Dept 6-6 Brown Bldg Ann Arbor MI 48109-2125
Telephone: 313/764-3364

The goals are to determine how roughness influences fluid film failure and material adhesion. In order to do this work it is necessary to characterize surface roughness thoroughly. We are measuring roughness by tracer, electron back-scattering and ellipsometry.

In the sliding experiments we observe the surfaces with ellipsometer and the other usual instruments. Our focus is on the initiating mechanisms of surface failure.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20 Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6 Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

HEAT GENERATION DURING ARTICULATION OF CO-CR-MO ALLOY ON UHMW POLYETHYLENE IN HIP AND KNEE PROSTHESES AND THE EFFECT ON CREEP AND WEAR RATES OF UHMWPE

J.A. DAVIDSON, G. SCHWARTZ, AND G. LYNCH

RICHARDS MEDICAL COMPANY, MEMPHIS, TENNESSEE

INTRODUCTION

Recent studies[1] have shown that significant amounts of heat can be generated during articulation of femoral prostheses. This heat can explain increased wear of acetabular components in-vivo. In addition to lubricant volume and cyclic load magnitude, the amount of heat generated is related to the articulating materials, with polished alumina ceramic against itself being low, against UHMWPE being moderate, and Co-Cr-Mo alloy against UHMWPE being high. The temperature of both the head and cup can easily reach 60° C in less than 30 minutes articulation time. This study was undertaken to determine if similar heating tendencies exist with a Co-Cr-Mo knee prosthesis articulating against UHMWPE under normal gait loading. The effect of the heat generated on the creep behavior of UHMWPE was also evaluated.

MATERIALS AND METHODS

Hip loading was applied as shown in Figure 1 with a peak load of 3560 N and a water lubricant level of 1 ml. Simultaneously, the cup was swiveled at one cycle per second. The cup was machined UHMWPE, and was articulated against a 32 mm diameter polished Co-Cr-Mo femoral head. The physiological knee load history was the same, during which the flexion ranged between 0° and 35° over a one-second interval. The articulating materials were the same as that used for the hip tests. The UHMWPE, in all testing, received 2.5 MRads gamma sterilization. The water lubricant level in the knee tests was sufficient to maintain a wet surface. During each test, temperature measurements of both surfaces were measured by briefly interrupting the test. Creep tests were performed on machined tensile specimens of UHMWPE at various temperatures for 30 minutes at an applied stress of 7.7 MPa.

RESULTS

Figure 2 shows the comparative amounts of heat generated in the hip and knee tests. Significant heat is generated in both systems, increasing with articulation time. Figure 3 shows the effect of temperature on the creep rate of UHWMPE. The heat generated can increase the creep rates several fold. Work is ongoing to evaluate the wear rate of UHMWPE at elevated temperatures.

SUMMARY

Although an issue not addressed previously, significant heat can be generated during articulation in both hip and knee prostheses under physiologic loading. This heat can increase the creep rate of the UHMWPE. The wear rate would likewise be expected to increase, thus explaining why in-vivo wear rates are greater than that generally predicted by conventional wear tests. A better understanding of this phenomenon is needed to optimzie long-term implant performance.

REFERENCES

[1] Davidson, J.A., and Schwartz, G., "Surface Heat Generation and Localized Creep During Articulation in a Total Hip", Proc. 33rd ORS, San Francisco, CA, Jan. 1987.

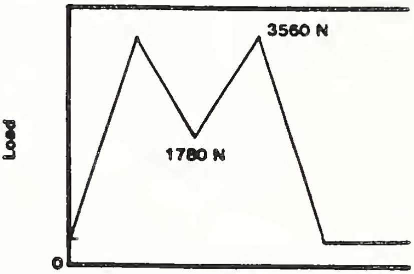

Figure 1. Load History

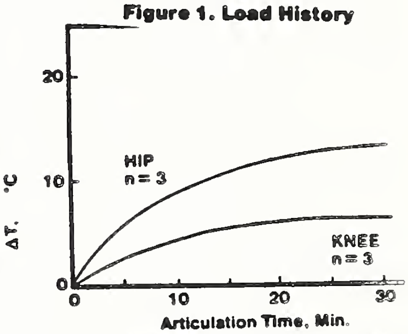

Figure 2. Heat Generation

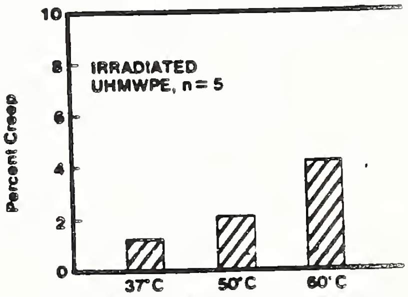

Figure 3. Effect of Heat on Cre

ease Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
10. Physical Properties
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Role of Chemical Affinity in the Frictional Behavior of Ceramics.

Name: N.H. Macmillan
Affiliation: Penn State Univ.
Address: 167 MRL, University Park, PA 16802
Telephone: 814 - 863 - 0180.

A study has been made of the sliding friction behavior of variously abraded like & unlike pairs of alkali halide single crystal surfaces in air of controlled relative humidity & ultra-high vacuum ($\sim 10^{-8}$ Pa). At low humidity the friction behavior correlates with anion-cation separation; & at high humidity boundary lubrication reverses the correlation. For NaCl, the friction is least at a relative humidity of 50%; for LiF it varies little with humidity, & is also little affected by non-renewable surface contaminants or surface roughness. Irradiating LiF affects its hardness & friction coefficient quite differently.

A theoretical calculation of the contributions of adhesion & plastic deformation to friction provides some insight into the process. Still unexplained is the physics of the formation of the very fine ($\leq$ 50 nm) wear debris particles formed.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Mechanisms of Wear in Single & Two-Phase Materials

Name: N.H. Macmillan
Affiliation: Penn State Univ.
Address: 167 MRL, University Park, PA 16802.
Telephone: 814-863-0180.

Angular 600 μm WC-Co particles have been used to erode & to wear (by a rolling-tumbling-sliding action) four single phase materials (Pb, Cu, Al_2O_3 & glass) & series of ductile-ductile (Pb-Cu), ductile-brittle (Pb-Al_2O_3), brittle-ductile (glass-Cu) & brittle-brittle (glass-Al_2O_3) composites made from them. In each case the volume fraction of dispersoid (Al_2O_3 or Cu) was varied from 0-40%; & the dispersoid particle size was held constant at ~ 200 μm. The variation of both forms of wear with microstructure is complex & does not fit any simple model.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
[✓ 7. Erosion]
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Erosion of Plain C Steels & Cast Irons.

Name: N.H. Macmillan
Affiliation: Penn State Univ.
Address: 167 MRL, University Park, PA 16802
Telephone: 814-863-0180.

A gas gun & a whirling arm erosion rig have been used to study the erosion of seven plain C steels & cast irons by 1.69 mm diameter WC-8% Co spheres over wide ranges of impact angle & velocity. At low impact angles, the erosion of the diphasic targets varies inversely as both static & dynamic hardness; at higher impact angles the correlation breaks down. Single phase Armco iron behaves very differently. The dominant process of material removal is the platelet mechanism for the more ductile targets; for more brittle targets other mechanisms also contribute.

Numerical modelling studies have also been undertaken to explore the effects on crater dimensions of some dependence of dynamic hardness on impact velocity.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
[✓ 7. Erosion]
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: ABSORPTION/DILUTION OF LUBE OIL IN HIGH PRESSURE CO_2 & N_2 GAS SYSTEMS

Name: GLEN M. MAJORS
Address: ROUTE #5, BOX 393
SEARCY, AR 72143
Telephone: 501 268-0267

Affiliation: C.E.S. ASSOCIATES, INC.
P.O. BOX 1408
SEARCY, AR 72143

RECIPROCATING COMPRESSORS HANDLING CO_2 OR N_2 GASSES IN THE 3,000 TO 8,000 PSI PRESSURE RANGE, ARE KNOWN FOR THEIR DIFFICULTIES TO LUBRICATE. PISTON RING WEAR, PISTON ROD PACKING RING EXTRUSIONS, AND PISTON SCUFFING AND FAILURES IN 300 HOURS IS NOT UNUSUAL. THE DESIRED LIFE IS 16,000 HOURS

RECENT FINDINGS:

1. THERE IS A REAL PROBLEM WITH ALL COMPONENT AS YET UNDEFINED
2. HIGH PRESSURE CO_2 & N_2 IS MISCABLE IN ALL PETROLEUM OILS AND GREATLY REDUCES THE OIL VISCOSITY
3. LIQUID WATER IS ALMOST ALWAYS PRESENT CREATING ACID ATTACK ON METALS AS WELL AS "WATER WASHING" THE OIL FROM METAL SURFACES
4. ASPHALTENES FORM AND DROP OUT INSIDE THE CYLINDER, INSIDE LIQUID TRAPS, AND ON INTERCOOLER TUBES
5. ANY HYDROCARBON GASSES IN TRACE QUANTITIES TEND TO LIQUIFY AND DILUTE THE "ONCE-THROUGH" OIL FILM.

FUTURE DIRECTION:

WE ARE MAKING GOOD PROGRESS WITH NEWER THERMOPLASTICS AND BETTER OIL FORMULATIONS.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: J. A. Marsi
Address: 4926 Elkridge Dr.,R.Palos Verdes,CA. 90274
Telephone: (213) 541-1350

Affiliation: Borg-Warner Ind. Products, Inc.
Pump Division
2300 E. Vernon Avenue
Vernon, CA. 90058

Various projects in large, high duty mechanical seals with hydrodynamic lubrication, used in primary coolant pumps at nuclear power generating plants (9" seal size, 2250 psi system pressure, 1200 rpm).

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tool/chip Interface Lubricooling Effect During High Pressure Waterjet Injection Study

Name: Dr. Marian Mazurkiewicz Affiliation: University of Missouri-Rolla
Address: Rock Mechanics, Rolla, MO 65401
Telephone: (314) 341-4316

Metal machining is the most basic of all manufacturing processes. The principal cost of shaping metal parts is generated both in the work involved in shearing metal from the original stock at the area where chip is formed and also in the work required to overcome the high frictional forces which exist between the chip and rake face. Current techniques for the lubrication and cooling of this area are not very effective, resulting in a machining cost which is much higher than it needs to be. A more efficient lubricooling effect can be achieved by the use of a high pressure water jet (40,000 psi) directed into tool/chip interface. Technical study conducted so far at RMERC indicated extremely good results and basic research need to be done to understand the nature of jet action. The results of this work will help to improve developed method (Invention Disclosure UMR-86-032) and utilized in industry at once.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: R&D of Fluids, Lubricants, Elastomers and Coatings

Name: B. D. McConnell
Affiliation: USAF
Address: AFWAL/MLBT, WPAFB, OH 45433-6533
Telephone: 513-255-9033

Project Goal: Develop nonflammable hydraulic fluid for -65° to 350°F, 8000 PSI operation.

Approach: Develop chlorotrifluoroethylene (CTFE) formulations and compatible elastomeric seals meeting the physical, chemical, and operational requirements.

Project Goal: Develop low temperature (-65°) less-flammable hydraulic fluid for -65°F to 275°F operation in current aircraft systems.

Approach: Tailor properties of polyalphaolefin basestocks to meet -65°F capability while maintaining fire resistant properties.

Project Goal: Develop -60° to 400°F, 4cSt turbine engine oil

Approach: Develop ester based candidates having required properties .

Future Directions: Establish program to develop high temperature (600° - 700°F) turbine engine oil in support of the high performance turbine engine initiative.

Establish inhouse tribology program to investigate surface interaction properties of solid lubricants in contact with metal/ceramic bearing surfaces. Determine the fundamental mechanisms governing adhesion, friction, and wear loading to the development of new/improved solid lubricant materials for advanced Air Force/SDI systems.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name:
Address:
Telephone:

Harry A. McKellop, M.S.
Orthopaedic Biomechanics
Orthopaedic Hospital - USC
2400 S. Flower St.
Los Angeles, Calif. 90007

Affiliation: UNIV. SOUTHERN CALIF. (USC)

Our program is based on a ten-station servo-hydraulic, microprocessor controlled joint simulator for friction and wear testing of prototype and production models of artificial human hip joint replacements. These joints typically consist of a "hard" ball (e.g., metal or ceramic) bearing against a "soft" (e.g., polyethylene) socket. The joints are usually run at about one cycle/sec under a load varying between 100 and 2000N (mimicking the human hip joint) with bovine blood serum lubrication. Frictional torque between the ball and cup is measured under static load. Wear is quantified by weighing the polymer cups. Variables examined include the type of polymer, processing techniques, amount of sterilization dose (gamma radiation), ball material (titanium alloy, cobalt-based alloy, stainless steel, alumina ceramic, pyrolytic graphite), ball-diameter, ball-cup clearance, surface finish, surface hardening treatments (e.g., nitriding, ion implantation, diffusion hardening, etc.). These variables are related to the durability of the surface of the "hard" ball and the resultant amount of wear of the soft polymer cup. Recent findings have been described in the following publications:

1. Clarke, I., McKellop, H., McGuire, P., Okuda, R., Sarmiento, A: Wear of Ti-6Al-4V implant alloy and ultrahigh molecular weight polyethylene combinations. In Titanium alloys in Surgical Implants, H. Luckey, F. Kubli, Eds., ASTM STP 796, ASTM, Philadelphia, 136-147, 1983.
2. McKellop, H., Clarke, I.: Degradation and wear of ultrahigh molecular weight polyethylene, In Corrosion and Degradation of Implant Materials, Syrett and Arharya, Eds., ASTM STP 684, ASTM, Philadelphia, 1985.

(over)

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
[✓ 6. Other (Please Specify)]
BODY FLUIDS, PROTEINS

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Coal Fired Diesel Research

Name: Richard L. Mehan
Address: P.O. Box 8, K1-MB-143
Telephone: Schenectady, NY 12301
(518) 387-6165

Affiliation: General Electric Company
Corporate Research & Development

Develop engine components, primarily piston rings and cylinder liners, that will survive running in a combusted coal water slurry. Approach is to screen materials and coatings on a ring-on-block and pin-on-disc machine, followed by bench testing in a four-inch single cylinder diesel engine running on a simulated coal fuel. Several promising coatings and materials identified, primarily in the tungsten carbide family of compounds.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED: [✓ 1. Friction] [✓ 2. Wear] [✓ 3. Lubrication] 4. Surface Damage 5. Failure 6. Fretting 7. Erosion 8. Adhesion [✓ 9. Abrasion] [✓ 10. Fatigue] 11. Load Capacity 12. Surface Temperature 13. Contact Stress 14. Film Formation 15. Oil Analysis [✓ 16. Life] 17. Filtration 18. Noise 19. Leakage 20. Other (Please Specify)	TYPE OF MOTION: [✓ 1. Sliding] 2. Rolling 3. Slide/Roll 4. Impact 5. Reciprocating [✓ 6. Oscillating] 7. Other (Please Specify)
VARIABLES CONSIDERED: [✓ 1. Load/Pressure] [✓ 2. Velocity] [✓ 3. Temperature] [✓ 4. Environment] [✓ 5. Dist/Time/Amp] [✓ 6. Geometry] [✓ 7. Finish/Lay] [✓ 8. Composition] [✓ 9. Structure] [✓ 10. Physical Properties] [✓ 11. Thermal Properties] [✓ 12. Chemical Properties] 13. Other (Please Specify)	LUBRICATION: 1. Unlubricated [✓ 2. Liquid Lubrication] 3. Gas Lubrication 4. Grease Lubrication 5. Solid Lubrication 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Val Mashrin
Affiliation: AVCO
Address: 550 S. Main St., Stratford, CT 06497
Telephone: (203) 385-3749

Avco Lycoming Division is one of industrial sponsors financially supporting the center for Engineering Tribology of Northwestern University, headed by Dr. Herbert S. Cheng The major objective of the center is to advance the understanding of the tribological processess controlling lubrication, friction, wear, and failure between two elastically or plastically deforming contact surfaces. Four major programs have been conducted by the center.

Prog. A - Thin - film lubrication breakdown.
Prog. B - Contact fatigue
Prog. C. - Surface film technology
Prog. D - Computer aided tribology

More detailed information can be obtained from Dr. Herbert S. Cheng, Center for Engineering Tribology, Department of Mechanical and Nuclear Engineering Northwestern University, IL 60201 Tel. (312) 491-3614.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
[✓ 7. Erosion]
8. Adhesion
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
18. Noise
19 Leakage
20 Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
3. Slide/Roll
4 Impact
5 Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
8 Composition
9. Structure
[✓ 10. Physical Properties]
11 Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3 Gas Lubrication
4 Grease Lubrication
5 Solid Lubrication
6 Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: William Milato
Affiliation: Amer. Soc. Lube Engrs
Address: 8215 Parkview Munster, Ind. 46321
Telephone: 219-838-9093.

Retired (forced) as Lubrication Engr of a major integrated steel mill - 1985 (25yrs) Have attempted to sale my expertise during the pass 18 mos.

B.S degree in Chemical Engr. All my working life since 1950 has been with petroleum products.

My observation during the pass 18 months indicates that entrepreneurship of the "make oil" variety has emerged.

William Milato
12/6/86

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: AN INVESTIGATION OF MODE II FATIGUE CRACK GROWTH DUE TO CONTACT LOADING

Name: Gregory R. Miller
Address: University of Washington, FX-10
Telephone: Seattle, WA 98195
(206) 543-0350

Affiliation: Department of Civil Engineering
University of Washington

The goals of this study are to derive a basic understanding of the mechanics by which a fatigue crack grows when subjected to the shear/compression loading arising in the contact between bearing elements, and to distill from this understanding a growth law which can be used in life prediction calculations. The present study is analytical in nature, although experimental studies are foreseen for future projects.

To date our work has focused on characterizing the crack tip behavior for subsurface cracks, including the mechanics of the branching of such cracks leading to pit formation. The remaining tasks will involve inclusion of plasticity and development of a growth criterion and growth law.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

SURVEY TO ASSESS THE CURRENT LEVEL OF TRIBOLOGY RESEARCH AND DEVELOPMENT ACTIVITIES IN THE UNITED STATES

Name: JOHN E. MILLER
Address: 9850 MERCER DR
DALLAS TX. 75228
Telephone Number:
214-321-0811

Affiliation: WHITE ROCK ENGINEERING, INC
P.O. BOX 740095
DALLAS, TX 75374
4109 MILLER PARK DRIVE
GARLAND, TX 75042

THE RECIPROCATING PUMP: Theory, Design and Use

by John E. Miller

From the Preface... "For many years there has been some confusion in the matter of the effects of liquid dynamics (flow variation and acceleration) on the performance of reciprocating pumps. One possible reason is the great difference between reciprocating and centrifugal pumps --those dealing with the latter usually are not confronted with the same types of disturbances. Another reason is the neglect that reciprocating pump theory has experienced in the midst of an increase in the problems resulting from high speed operation as the result of manufacturers frequent speed-up ratings applied over the years due to the pressure of competition and economics..."

THE RECIPROCATING PUMP: Theory, Design and Use represents the most complete collection of Reciprocating Pump technical and practical information ever assembled. For the first time, many practical aspects of a reciprocating pump have been combined with theory to provide a convincing explanation of previous mysterious and misunderstood parameters, including liquid acceleration, acoustics and NPSH. Chapter by chapter, the following topics are covered:

Pump Types - Dynamics - Net Positive Suction Head - Pulsation and Surge Control
Pump Design - Liquid Ends - Expendable Parts - Valves - Slurry Pumping
Part Wear and Life - Applications - Instrumentation
Theory of Flow in Pump - Appendix

The section on Slurry Pumping goes into great detail on the subject of the relatively new industry of transporting solids in the form of a liquid slurry by the use of Reciprocating Pumps. In order to provide a comprehensive encyclopedia of reciprocating pumps, chapters 13 and 14 contain many useful tables, charts, conversions, etc. enabling the reader to carry a pumping project from conception to retirement.

Many subjects in this book are covered by means of discussion, allowing the reader to better understand the cause and effect. In many cases, examples of calculations and derivations are given to support the explanation. Historical aspects, aside from their casual interest, serve as a warning on the use of unworkable ideas, or they may inspire new ideas.

For more information, see reverse...

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: COMPRESSOR OIL DEVELOPMENT

Name: Glenn D. Short, Manager, Development
Affiliation: CPI ENGINEERING SERVICES, INC.
Address: PO Box 1924
Telephone: (517) 496-3780

PROJECTED GOALS

Synthetic fluids and unique semi synthetic fluids derived by high temperature hydrocracking of mineral oils are being examined for oxidative; chemical; thermal and physical properties.

METHOD OF APPROACH

Exposure to various environments under laboratory conditions and compressor field testing

RECENT FINDINGS

- Energy savings for centrifugal compressors
- Long life in air compressors - examine new base oils and antioxidants
- Hydrotreated (hydrocracked) ISO paraffinic oil formulated for ammonia refrigeration applications
- Unique polyolester for low evaporator temperature / energy efficient operation in rotary screw refrigeration compressors
- Corrosion inhibitor for gas compression with H_2S

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
10. Physical Properties
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

TITLE: TRIBOLOGY OF STRUCTURAL CERAMICS, CERAMIC COATINGS, AND CERAMIC COMPOSITES.

NAME: KAZUHISA MIYOSHI, Ph.D. AFFILIATION: NASA-LEWIS RESEARCH CENTER.
ADDRESS: M.S. 23-2, 21000 BROOKPARK ROAD, CLEVELAND, OHIO 44135
TELEPHONE: (216) 433-6078

GOALS: To understand the fundamental mechanisms involved in adhesion, friction, lubrication, and wear of ceramic materials, both bulk and coating structure, as well as the properties of materials which influence their tribological behavior.

METHODS OF APPROACH: To control and characterize as carefully as possible the materials and environment in tribological studies.

RECENT FINDINGS: Heating of a ceramic such as SiC to high temperatures can result in the graphitization of the ceramic surface with the graphite functioning to reduce adhesion and friction. A lubricating film is therefore provided from the material itself.

FUTURE DIRECTIONS: Fundamental and focused research to develop high-temperature ceramics for use as components in mechanical systems such as advanced propulsion systems.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
[✓ 7. Erosion]
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: FRICTION AND WEAR OF UNIDIRECTIONAL AND WOVEN CARBON FIBER REINFORCED POLYETHERETHERKETONE (PEEK) COMPOSITES

Name: PARIMAL B. MODY
Affiliation: Graduate Research Assistant.
Address: DEPT OF MECH. ENGG, UNIVERSITY OF DELAWARE, NEWARK, DE 19716.
Telephone: (302) 451-6604.

Three categories of materials, the neat PEEK matrix, its unidirectional, and its two-dimensional woven composite were investigated under two types of testing conditions: abrasive-dominant (pin-on-flat type, counterface: abrasive paper) and adhesive-dominant (pin-on-disc type, counterface: polished steel). The behaviors were characterized by the experimentally determined wear rates and the coefficients of friction, and by the observation of the worn surfaces and sub-surface regions on an SEM.

Abrasive wear rates, which decreased with increasing apparent area, displayed a greater sensitivity to fiber orientation than did the friction. In-plane unidirectional fibers oriented parallel to the direction of sliding, and the woven surface possessing a combination of in-plane parallel (80%) and in-plane transverse (20%) fibers showed maximum wear resistances for the two composite systems. A modified rule-of-mixtures approach was developed to predict the w-ar behavior of the woven composite.

Sliding wear rates, on account of their being extremely sensitive to the microstructure of the surface being worn, were over five orders-of-magnitude lower than for abrasive wear. Complex interactions arising due to the effects of the testing parameters like fiber orientation, sliding velocity, contact pressure, and the interface temperature were characterized for the neat matrix and the two composite systems. Wear rates increased with (pv)-values: with temperature, they first increased, attained a maximum around the glass transition temperature of the polymer, and then decreased slightly.

Finally, a design guideline that will aid an increased utilization of these self-lubricating materials was developed in the form of (pv)-diagrams.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
[✓ 5. Dist/Time/Amp]
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: None

Name: Stu Moffitt Reed Tools
Affiliation: ASME, ASLE, SPE
Address: 7000 HOLLISTER, Suite 200 Houston, TX 77040
Telephone: 713 744-3634

Ongoing research to identify and understand the behavior of floating bushings in a pressurized grease environment. Very high loads and low rotary speeds are common. ~~Estimated~~ Acceptable life ratings of 200 hours are targeted.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
[✓ 5. Failure]
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
[✓ 5. Dist/Time/Amp]
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Laser Surface Modification of Metallic Materials for Improved Wear, Erosion, Corrosion and Fatigue Performance

Name: P. Molian
Affiliation: Iowa State University
Address: 2092, ME/ESM Building
Telephone: 515-294-2101

Efforts were and are being made to enhance the service performance of several engineering components through laser surface modification procedures that include heat treating, glazing, alloying and cladding. Emphasis is placed upon fundamental understanding of these processes on materials, the objectives being to conserve strategic and expensive materials and to improve the tribological qualities. A brief description of individual topics and their scopes is given below.

(1) Laser Surface Hardening of Gray and Ductile Cast Irons. Surface hardening of cast irons via a laser beam and its effects on sliding wear, erosive wear and rotational fatigue behavior were investigated.

(2) Laser Deposition of BN/TiN films on Cutting Tool Edges. High power CO_2 lasers were used to evaporate BN and TiN from abrasive wheels and to deposit such films on high-speed tool steel and cemented carbide substrates. Hardness, microstructure, and film thickness were determined and were related to tool wear. Performance of coated tools at high speeds is being investigated.

(3) Laser Surface Alloying of AISI 4140 and 4340 steels to improve wear and corrosion. Chromium, nickel and molybdenum metals either individually or in combination were deposited on low-alloy steels through a laser surface alloying process. Novel microstructures and high hardness were found in laser-processed coatings. Sliding wear, erosive wear and electrochemical corrosion of alloyed layers are being studied.

(Continued on attached sheet)

APPLIED RESEARCH

(4) Laser cladding of thermal barrier coatings. Thermal barrier coatings such as Zro_2/y_2o_3 and Al_2o_3 were clad on a superalloy substrates successfully with high power lasers. Effects of claddings on high-temperature performance such as oxidation and erosion are being evaluated.

(5) Laser cladding of titanium alloys for improved wear performance. Ti and its alloys exhibit poor friction and wear properties due to the presence of oxide film and high surface tension. A laser cladding approach will be used to alleviate these problems. Coating materials include MON, Tribaloy T-800 and BN.

The major goal of these projects is to understand the influence of laser-processed coatings (coating thickness, microstructure, hardness, surface topography and integrity, coating/substrate interface, composition gradient etc.) on the wear processes.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: MICRO-LUBRICATION

Name: Bryan K. Mocny
Affiliation: ALL AUTOMOTIVE, MACHINE TOOL OEMS, AND MFG FACILITIES
Address:
Telephone:

DEVOLPMENT AND DESIGN SUBJECTS SYSTEMS TO SPECIFIC'S ASSOCIATED WITH BEARING TYPES, MATERIALS AND SURFACED USED TO BUILD MACHINE TOOLS.

DESIGN ON LINE LUBRICATION FOR PREPRODUCTION ASSEMBLY.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
[✓ 7. Erosion]
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
16. Life
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
[✓ 4. Impact]
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
[✓ 7. Other (Please Specify)]
ALL SURFACE CONTACTS
REQUIRING MED. +
INTRUSION - IE TAP + DIE USE

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: DEVELOP A PRODUCT FOR Bicycle Chains, and the lik that will satisfy users in Japan.
Name: EWELL E. McDOLE
Affiliation: NORTHERN CALIF SECTION
Address: 374 LAUREL DR., Danville, CA
Telephone: 415-837-5778

THE PRODUCT MUST LUBRICATE AND PREVENT CORROSION IN BICYCLE CHAINS WHILE USED IN WET AND DUSTY CONDITIONS. IT MUST ALSO BE EASILY REMOVED WITH PETROLEUM SOLVENTS TO LEAVE CHAINS CLEAN – AND READY FOR RE-LUBRICATION. IT MUST ALSO SERVE USER WELL AS AN ASSIST IN polishing CHROMIUM PLATING – by LOOSENING RUST AND DELAYING ADDITIONAL RUSTING.

SUBSEQUENTLY ADDITIONAL REQUIREMENTS HAVE BEEN ADDED — BUT TO DATE I HAVE NOT, NOR DO I EXPECT TO, PROVIDED ONE PRODUCT SATISFACTORY FOR ALL POSSIBLE USES WITH ALL METALS.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify) Water displacement, RUST Loosening, and RUST INHIBITION

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify) Bicycle chains – wet & dry

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify) see above answer

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROGRAM ~~PROJECT~~ TITLE: Relating Bearing & Steel Performance to Tribological Factors

Name: Charles A. Moyer
Affiliation: The Timken Company
Address: 1835 Dueber Ave., S.W., Canton, OH. 44706
Telephone: (216) 497-2006

Tribological factors are concentrated in lubrication, temperature and other environmental aspects.

Unfortunately, we cannot give the specific projects that make up our general program or the methods, specific bearings involved since our work is strongly applied research related and so is considered proprietary to the Company.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
[✓ 17. Filtration]
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify) Surface Roughness
(broader concept than 7)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: JOHN J MURPHY
Address: BARDEN CORP
Telephone: 203-744-2211

Affiliation:

OUR DEVELOPMENT LABORATORY AND MANUFACTURING ENGINEERING GROUP ARE CONSTANTLY REVIEWING AREAS CHECKED BELOW. THE ONGOING WORK IS NOT IN THE FORM OF SPECIFIC PROJECTS BUT RATHER EVALUATION OF PRODUCT, MANUFACTURING METHODS, PRODUCT PERFORMANCE, COATING EVALUATION, NEW LUBRICANTS AND LUBRICANT APPLICATION, NEW MATERIALS, MACHINING METHODS, SPEED AND WEAR EFFECTS, MEASUREMENT OF TORQUE, COEFFICIENT OF FRICTION AND BEARING RELATED NOISE.

SOME OF THE WORK IS INFORMALLY REPORTED BUT WE ARE STARTING A MORE COMPLETE REPORTING METHOD. WE SHOULD LIKE TO BE A PARTICIPANT IN THE PROGRAM TO ASCERTAIN AREAS OF WORK SO CONTACTS FOR INFORMATION EXCHANGE COULD BE EFFECTED.

THANK YOU FOR THIS CONSIDERATION

John J Murphy

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11 Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
[✓ 18. Noise]
19. Leakage
20 Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
[✓ 4. Impact]
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4 Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13 Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Effect of Surface Topography on Thin Film Lubrication of Sliding Surfaces.

Name: S. Frank Murray
Affiliation: Senior Research Engineer
Tribology Laboratory
Address: M.E. Dept., RPI, Troy, NY 12181
Telephone: (518) 266-6977

Objective: Determine which of the measured or calculated surface texture parameters influence thin film lubrication of sliding surfaces

Methods of Approach: Both experimental bench tests and analytical studies.

Recent Findings: Partially reported in Ref.1*

Future Directions: Continue work using synthetic hydrocarbons as lubricants.

* Ref.1 "Surface Texture Effects in Thin Film Lubrication of Steel by Silicones," J.D. Cogdell, M.C. Dawson, F.F. Ling and S.F. Murray, ASLE Preprint No. 86-AM-8E-2. Presented at 41st Annual ASLE Meeting, Toronto, May 12-15, 1986.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: IMPROVEMENT OF HIGH TEMPERATURE WEAR RESISTANCE IN SLIDING AND CONCENTRATED CONTACT WEAR.

Name: Dr SIMON NARASIMHAN
Address:
Telephone: EATON CORPN.
ECD ENGINEERING CENTER
HOMER RD MARSHALL
MI 49068

Affiliation:
R&D SUPERVISOR
MATERIALS & BASIC PROCESSES.

OBJECT: TO IMPROVE WEAR RESISTANCE AND DURABILITY OF VALVE STE AND VALVE SEATS IN INTERNAL COMBUSTION ENGINES.

APPROACH: 1) CHOICE OF PROPER MATERIALS SUPERALLOYS, COATINGS, THERMAL TREATMENTS etc.

2) CHOICE OF SPECIAL PROCESSING: POWDER METAL COMPACTION, UNIQUE MIXTURES

3) INHERENT HIGH TEMPERATURE LUBRICATION : SOLID LUBRICANT ADDITIONS.

FINDINGS SOLID LUBRICANTS' ROLE HAS BEEN IDENTIFIED FOR MOS_2, TALC etc. ALUMINA REFRACTORY POWDERS OFFER ADDED WEAR RESISTANCE.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
[✓ 15. Oil Analysis]
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Bending Pad Thrust Bearing

Name: H.G. Anderson
Affiliation: David Taylor Naval Ship R&D Center
Address: Code 2723, DTNSRDC, Annapolis, MD 21402-5067
Telephone: (301) 267-2362

A new thrust bearing has been invented (U.S. Patent No. 4,240,676) that operates on the principle of bending in lieu of tilting to form the necessary hydrodynamic lubricating wedge. The supporting structure for the pad is weakened around the leading and trailing edges to allow a convex surface. This is accomplished by either grooving the support structure or utilizing a variety of rubber-type backing supports.

Initial investigations of model bending pads at Columbia University under DTNSRDC contract shows improved performance over centrally supported rigid tilting pad bearing shoes with plain babbitted bearing surfaces. Further improvement was shown with test samples having dimpled surfaces. Further tests are planned in FY87 to optimize the design.

The new design shows promise carrying higher bearing loads with greatly simplified mounting and support structures greatly reducing first cost and maintenance. Plans are to apply the findings to future thrust bearing designs for naval machinery.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9 Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
[✓ 14 Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20 Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5 Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4 Environment
5 Dist/Time/Amp
6 Geometry
[✓ 7. Finish/Lay]
8. Composition
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3 Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

~~Please type all in~~formation and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: PLASTIC AIRDUCT (TELESCOPING) RING BEARINGS.

Name: Alan L. Newcomb
Affiliation: Teledyne INET.
Address: 26847 Fond Du Lac Rd., RPV, CA 90274
Telephone: (213) 325-5040

IMPROVEMENT & COST REDUCTION OF A STANDARD PRODUCT – BY MATERIAL SUBSTITUTION AND DESIGN SIMPLIFICATION.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify) WEATHER RESISTANCE

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify) FABRICATION ECONOMICS.

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify) SELF LUBRICATION

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Roger K. Nibert
Affiliation: Borg-Warner Research Center
Address: Wolf & Algonquin Roads Des Plaines, IL 60018
Telephone: (312)827-3131

Major Areas:
1. R&D on wet clutch materials for transmission systems.
2. Hard wear resistant coatings.
3. High temperature lubricants and additives.
4. Oscillating contact bearing lubrication.

Methods of Approach

Lab simulation of tribo systems with emphasis on duplication of failure modes expected or known to occur in full scale endurance and field testing of complete systems. Failure mechanisms are established based on wear particle analysis, surface analysis, and lubricant degradation.

Correlation of lab-endurance-field testing with emphasis on efficient screening of new materials and field life projection.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
[✓ 16. Life]
[✓ 17. Filtration]
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: INVEST. OF EFFECTS OF RUN-IN WEAR ON DYNAMIC PERFORMANCE OF CAMS MADE BY VARIOUS METHODS

Name: ROBERT L. NORTON Affiliation: WORCESTER POLYTECHNIC INST.
Address: MECH ENG. 100 INSTITUTE RD WORCESTER MA. 01609
Telephone: 617 793 5537

GOALS: DETERMINE THE EFFECT OF MANUFACTURING METHOD AND SURFACE FINISH ON THE DYNAMIC PERFORMANCE AND RUN-IN WEAR OF CAM-FOLLOWER SYSTEMS.

METHODS: ≈ 50 CAMS HAVE BEEN MADE BY VARIOUS METHODS TO BE TESTED ON OUR CUSTOM CAM DYNAMIC TEST FIXTURE (CDTF) CAM SURFACE PROFILE IS MEASURED WITH A HOMMEL T20S SURFACE ROUGHNESS TESTER. THE CAM IS THEN RUN UNDER CONTROLLED LOAD & LUBRICATION AND THE FOLLOWER ACCELERATION, FORCE AND SLIP ARE MEASURED DYNAMICALLY. THE PROCESS IS REPEATED AND THE CHANGES IN THE SURFACE PROFILE TRACKED.

FINDINGS: STATISTICALLY SIGNIFICANT DIFFERENCES EXIST BETWEEN MILLED AND GROUND SURFACES IN TERMS OF THEIR SURFACE PROFILE CHARACTERISTICS AND DYNAMIC PERFORMANCE
THE RUN-IN PROCESS IS VERY SLOW - ONLY SLIGHT CHANGES HAVE BEEN SEEN SO FAR

DIRECTIONS: CONTINUE THE TESTING TO INVESTIGATE EFFECTS OF RUN-IN WEAR ON DYNAMIC PERFORMANCE

(Please Circle All Appropriate Parameters)

SEE ALSO ATTACHED PAPER

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify) ACCELERATION

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: DESIGN AND DEVELOP 8000 PSI NON-FLAMMABLE FLUID (CTFE) HYDRAULIC COMPONENTS

Name: Frederick W. Perian Affiliation: Vickers, Incorporated
Address: 5353 Highland Drive, Jackson, Mississippi 39206-1177
Telephone: (601) 987-3412

PROJECT GOALS:

Develop criteria for the design of hydraulic components that will operate on Chlorotrifluoroethylene (CTFE) fluid at 8000 psi system pressure.

APPROACH:

Design analysis of 3000 psi, 4000 psi and 5000 psi hydraulic components.

Establish PV factors for sliding surfaces with CTFE fluid medium.

CTFE has promise for use as the fluid medium in a hydraulic system.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
[✓ 7. Erosion]
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
14. Film Formation
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Friction Materials Dynamomemeter Methodology

Name: Dr. David T. Patten
Address: P.O.Box 238, Troy NY 12181
Telephone: (518)-273-6550

Affiliation: Allied Automotive
Bendix Friction Materials Division

GOAL: To develop a fundamental understanding of friction materials and shorten test duration through new testing technologies.

APPROACH: Combine computerized data acquisition, varing test cycles and response modeling to predict the results of conventional testing.

RECENT FINDINGS: Pretest environmental conditions have long presistance effects on friction levels with some materials, but not with other types of friction materials

FUTURE DIRECTIONS:
1. Develop tests with conbined preconditioning and dynamometer testing to better reflect field testing and actual use.
2. Develop methods to scale full sized testing to smaller test machines.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Darrell W. Patton
Affiliation: Lubrication Engineers Inc.
Address: P. O. Box 16447, Whchita, KS 67216
Telephone: (316) 529-2112

I am involved in various projects to develope commercial lubricants for industry, etc. which provide increased levels of wear reduction, service life, load carrying capacity, thermal stability, etc.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
[✓ 6. Fretting]
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
16. Life
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: LUBRICATION WITH NATURALLY OCCURING OXIDES

Name: M B PETERSON
Affiliation: WEAR SCIENCES CORP
Address: 925 MALLARD CIRCLE ARNOLD MARYLAND 21012
Telephone: 301 261 2342

Studies are being conducted of the lubricating characteristics of oxide and mixed oxides over a wide temperature range. Alloys or coatings are being prepared which contain the necessary metal ingredients to form such films in an oxidizing atmosphere. Friction tests are being run to measure the tribological properties of the developed materials

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Michael R. Philpott
Affiliation: IBM Almaden Research Center
Address: 650 Harry Rd, San Jose, CA. 95120
Telephone: 408-927-2440.

Basic research into fundamental mechanisms in tribology especially as they relate to magnetic recording. Areas of interest are polymeric liquid lubricants, durable hard coatings, tribology in carefully controlled ambient conditions (eg., UHV), insitu measurements of pressure, temperature, wear etc. Use of scanning tunnelling and atomic force microscopy to study microscopic tribological phenomena. Emphasis on long range research that will provide fundamental understanding.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)
Flying (slider - disk air bearings)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
[✓ 3. Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: JACK POLEY
Affiliation: LUBRICON® (Same address)
Address: 350 E. CHURCHMAN, INDIANAPOLIS 46107
Telephone: (317) 783-2968

WE ARE INVOLVED IN THE COMMERCIAL OFFERING OF "OIL ANALYSIS" FOR MAINTENANCE DIAGNOSTICS PURPOSES. OUR PHILOSOPHY CENTERS AROUND STATE-OF-THE-ART TESTING CONCEPTS ROUTINELY APPLIED, AS WELL AS EXTENSIVE USE OF COMPUTERIZATION IN EVALUATING DATA.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

all

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: George C. Pratt Affiliation: Federal-Mogul Corporation
Address: 3990 Research Park Drive, Ann Arbor, MI 48104-7592
Telephone: (313) 995-8593

PROJECT TITLE: Aluminum Bearing Alloy Development

Develop improved aluminum plain bearing alloy and associated casting process and process for bonding to steel strip. Study effect of alloy composition and quench rate on bearing performance.

PROJECT TITLE: PTFE Based Bearing Material Development

Develop steel backed PTFE based dry bearing material and associated strip manufacturing processes. Study effect of composition on bearing performance.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
[✓ 7. Erosion]
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Development of a New Space Lubricant

Name: Dr. Robt E. Pratt
Address: 5814 E 61st St, LA, CA 90040
Telephone: (213) 727-7792

Affiliation: Technolube Div.
Lubricating Specialties Co.

We are requesting a Phase II proposal to develop a Silahydrocarbon Space Lubricant. Wright Patterson Air Force Base is our contact.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. [✓ Wear]
3. [✓ Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. [✓ Sliding]
2. [✓ Rolling]
3. [✓ Slide/Roll]
4. Impact
5. Reciprocating
6. [✓ Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. [✓ Load/Pressure]
2. Velocity
3. [✓ Temperature]
4. [✓ Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. [✓ Physical Properties]
11. [✓ Thermal Properties]
12. [✓ Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. [✓ Liquid Lubrication]
3. Gas Lubrication
4. [✓ Grease Lubrication]
5. [✓ Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: NON-MIST AIR/OIL LUBRICATION OF HIGHSPEED BEARINGS WITH DN FACTORS GREATER THAN 10^6.

Name: PETE KAMIS
Affiliation: LUBRIQUIP-HOUDAILLE, INC
Address: 18901 CRANWOOD IND'L PKWY, CLEVELAND, OH 44128
Telephone: (216) 581-2000

GOAL: ESTABLISH THE SUPERIORITY OF NON-MIST AIR/OIL LUBRICATION COMPARED TO CIRCULATING OIL, MIST, AND GREASE PACK FOR HIGH SPEED BEARINGS USED IN MACHINE TOOL SPINDLES.

METHODS: USING ACTUAL SPINDLE HEAD WITH SIMULATED LOADS APPLIED USING HYDRAULIC CYLINDERS, TEMPERATURE RISE ABOVE AMBIENT WAS MEASURED AT THE BEARING HOUSINGS FOR DIFFERENT METHODS OF LUBRICATION.

FINDINGS: THE NON-MIST AIR/OIL METHOD GENERALLY RESULTS IN LOWER TEMPERATURE RISE FOR DN VALUES GREATER THAN 2.5×10^5.

FUTURE DIRECTIONS: ISOLATE FACTORS WHICH STILL CONTRIBUTE TO PREMATURE BEARING FAILURES EVEN WITH THIS METHOD OF LUBRICATION, PRIMARILY OCCURING AT DN GREATER THAN 10^6.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
[✓ 13. Other (Please Specify)]

LUBRICANT VOLUME + FREQUENCY OF LUBRICATION.

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
[✓ 6. Other (Please Specify)]

AIR/OIL (NON-MIST) LUBRICATION.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: TRIBOLOGY OF RIGID DISK DRIVES

Name: MUKUND RAO
Affiliation: CONTROL DATA CORPORATIO
Address: 7501 COMPUTER AVE. S, MINNEAPOLIS, MN 55435
Telephone: (612) 530-7212

- FRICTION & WEAR OF HEAD/DISK INTERFACE IN RIGID DISK DRIVES
- EVALUATE & DEVELOP LOW FRICTION, LOW WEAR HEAD/DISK COMBINATIONS
- EVALUATE PROTECTIVE COATINGS, MATERIAL COMPATABILITY
- STUDY EFFECTS OF TEMP., HUMIDITY, DYNAMICS (VIBRATION etc.)

DETAILS ARE PROPIETARY INFORMATION

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
[✓ 7. Other (Please Specify)]
SLIDE/IMPACT

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Coating Development for Small Engines.

Name: F. Rastegar
Affiliation: Briggs & Stratton
Address: 7219 W Marine Dr. Milwaukee, WI 53223
Telephone: 414/259-5333

Project Goal: To develop wear resistant coatings at reasonable cost for Small Engines.

Approach: Physical Vapor Deposition, Electroplating & Plasma spray.

Findings: Industrial Secret (Can Not be published at this stage of the project).

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
[✓ 8. Composition]
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: ① Mini Lubrication Test ②/ Defect Occurrence & Growth Test

Name: Richard P. Reiff
Affiliation: Association of American Railroads
Address: Transportation Test Center, Pueblo, CO 81001
Telephone: (303) 545-5660

① Mini Test will examine 14 lubricants of variable makeup. Lubricants will be applied manually on the rail in the field. A test train will make a number of passes over the site and measurements taken to determine lubricant effectiveness. Lubricant characteristics will be determined for retentivity, flowability and spreadability. A number of laboratory correlation tests are also planned.

② Defect Test. Lubrication has been shown to effectively increase the wear life of rail to where fatigue effects are seen. This study uses lubrication to extend rail life under conventional train operation while monitoring fatigue life of various test rails.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)] Application Systems

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Wear behaviour of the couple UHMWPE-Ti6Al4V for hip joint prosthesis.

Name: R. MARTINELLA Affiliation: CISE
Address: P.O. BOX 12081, 20134 MILAN ITALY
Telephone: 02/2167 2345

- Comparison of the wear rate of UHMWPE coupled with: 1) diamond lapped Ti alloy; 2) diamond lapped + N-implanted Ti alloy, 3) Ti6Al4V lapped according to a special procedure set up at CISE and with AISI 316 and VITALLIUM
- The goal is to reduce the wear rate of polyethylene by changing the surface chemistry of the metallic antagonist in order to reduce the adhesive affinity of the couple. Adhesion is in fact responsable of the wear of UHMWPE.
- Test conditions: laboratory tests ~~with~~ with an annulus on metallic disc tribotester. Test conditions (pressure, velocity, oscillating angle) simulate those in a hip joint. Environment: H_2O.
- UHMWPE wear rate coupled with diamond lapped Ti alloy is ~ 10 times higher than the wear rate displayed by the other couples. The best behaviour was shown by the couple polyethylene-implanted Ti alloy. The wear rates correlate well with the adhesive transfer and with the surface chemistry determined by ESCA and AUGER analisys. Laboratory wear rates on AISI 316, VITALLIUM and Ti6Al4V alloy lapped according to the special procedure compare very well with those data on simulator for hip prosthe.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
[✓ 13. Other (Please Specify)]
Materials and surface treatment and finishing

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: EROSION of burner tips, pumps, valves and pipes for CWS (coal water slurry

Name: R. MARTINELLA Affiliation: CISE
Address: P. O. Box 12 081 MILAN ITALY
Telephone: 02/21 67 2345

GOALS: to increase the service life of these components by using appropriate materials.

METHODS: a) evaluation of the erosion rate of the real component by means of field tests in a pilot plant. This was carried out for burner tips (diameter increasing rate of the discharge orifices of a tool steel burner tip: 2.5 mm/y and is going on for pipes, valves and pumps on a specially designed loop facility.

b) set up of a simulative laboratory test procedure in order to characterise the erosion resistance of candidate materials.

FINDINGS #1) Laboratory jet impingement tests at different impact angles an velocities in order to classificate the erosion resistance of candidate ceramics and cermet materials (more than 30) for burner tips. Very good comparability of laboratory and field tests was fo both from the relative performance of materials as well as fr the absolute erosion rate point of view. Long lasting tests are now in progress on two kinds of selected materials.

#2) laboratory slurry jet tests were carried out on carbon steel as a material for pipes at different velocities and impact angle. The erosion rate depends linearly on the test velocity and is independent of the impact angle. Slurry jet data at ≃ 1 m/sec give an erosion ra of ~ 0,2÷ mm/y i. quite comparable with published data from loop tests with CWS. Slurry jet d will be comp with the dat obtained o the loop as soon as these field t will be completed.

#3) For pumps and valv only field tests are plann

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1 Friction
2 Wear
3 Lubrication
4. Surface Damage
5. Failure
6 Fretting
[✓ 7 Erosion]
8 Adhesion
9 Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15 Oil Analysis
16 Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1 Sliding
2. Rolling
3 Slide/Roll
4 Impact
5 Reciprocating
6 Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1 Load/Pressure
2 Velocity
3 Temperature
4 Environment
5 Dist/Time/Amp
6 Geometry
7. Finish/Lay
8 Composition
9 Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
[✓ 13 Other (Please Specify)]

LUBRICATION:

1 Unlubricated
2 Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6 Other (Please Specify)

* for pumps and valves on the loop: materials, velocity;

* for pipes on the loop facility: cws velocity, bending radius of bends, sloping (vertical, horizontal pipe) materials, cws erodent properties (erosivity)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

Project Title: Studies of Actual Viscosity of Oil Between Friction Plates During Operation in a New Patented Brake Design.

Name: David A. Renfroe   Affiliation: U of Arkansas
Roger A. Iverson   RAI Associates

Address: Mechanical Engineering Department
Room 204 B
Fayetteville, Arkansas 72701
Telephone: 501/575-3040

A wet clutching/brake mechanism has been designed to operate as perscribed in a patent issued to R.A. Iverson in 1982. A key element in this design is to allow high radial oil flow rates through the clutch plate stack to carry the heat generated during the power absorbtion away from the clutch disks. A demonstration device was constructed and tested and was found to absorb 5.78 x 10^{-3} Kw/sq.cm. (0.05 HP/sq.in.) of clutch plate surface area with no supplimental oil cooling. As a result of the new design, an equal fraction of torque was transmitted through each of the disks in the clutch pack and no wear of the clutch plates was discernable after several hours of high energy rejection operation.

The research presently being conducted is to determine the mechanism of the energy absorbtion process and use this knowledge to design better brakes and clutches for particular applications. Insight into the actual viscosity of a fluid between surfaces moving with a relative velocity will be developed. The near term objective is to continue the study of this fluid boundary by investigating the effect of air entrainment, particle contaminants, shear rate, surface roughness, and surface geometry on the actual viscosity of a fluid as compared to that measured by the Saybolt viscometer.

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: 8000 PSI

Frank Rerecich Repr
Name: Marotta Scientific Controls, Inc. Affiliation: SAE, ASLE
Address: P.O. Box 330, Boonton, New Jersey 07005
Telephone: 201-334-7800 Extension 423

GOALS

Determine the Frictional Force required to be overcome in Balanced Poppet Valve Seals used in 8000 PSI Hydraulic Systems.

Preliminary indications are that the Seal Friction using CTFE Oil is larger than using MIL-H-83282 Hydraulic Oil.

Future work will be devoted to refining the Friction Force measurement Techniques to take Velocity into account.

Rod Size - 0.1546 Reciprocating Motion - .010" maximum

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
[✓ 18. Noise]
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Chemostress Effects in Metal Removal Processes

Name: V. H. Desai and S. L. Rice Affiliation: University of Central Florida
Address: Mechanical Engineering and Aerospace Sciences, UCF, Orlando, FL. 32816
Telephone: (305) 275-2416

It has been established that environmental factors affect fracture processes. Thus, in wear, in corrosion, and in machining operations of all kinds, the role of the environment is significant. It follows that the change in the chemical potential of ions close to tribosurfaces, due to local stress and temperature gradients, will influence the near-surface chemical balance. Thus, it should be possible to utilize simple electrochemical controls to achieve improvements in wear and corrosion resistance, as well as in the efficiency of machining operations such as milling, grinding, etc.

The research which is directed toward improving our understanding of the above factors utilizes a specially developed tribotester. This apparatus allows specimens to be subjected to various levels of "externally applied static stress" while submerged in fluids having given bulk electrolytic properties. The applied stress is superimposed upon the stress field which exists at the tribocontact so as to allow the effect of stress on ionic activity and chemical potential to be deduced.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: In Situ Investigation of Wear of Materials by Laser Speckle

Name: F. A. Moslehy and S. L. Rice Affiliation: University of Central Florida
Address: Mechanical Engineering and Aerospace Sciences, UCF, Orlando, Florida 32816
Telephone: (305) 275-2416

A wear specimen develops three characteristic zones which differ in composition and morphology. The near-surface region usually is "chemically mixed", consisting of species from specimen, counterface and environment. The intermediate region usually is plastically deformed but compositionally unaltered. The far-surface region consists of material which is "original" both in composition and morphology. The particular characteristics of these zones depend upon the materials, environment and the conditions of tribocontact, and it is of importance to understand their development.

A laser speckle technique is being developed to study the formation and growth of these subsurface zones by means of observations made on the surfaces of wearing specimens. The work includes the experimental determination of the interfaces between the compositionally mixed and severely plastically deformed zones, as well as the measurement of associated deformations. Laser speckle surface measurements will be correlated with metallographic observations on subsurface zones. The goal is the determination of displacement/time histories for wear specimens in order to allow the development of engineering models for wear.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: To Maximize The Efficiency Of Wire Drawing & Rolling Mill Emulsions Using Continuous Cast Nonferrous Rod

Name: Ronald Reich, V. P. R & D Affiliation: G. WHITFIELD RICHARDS COMPANY
Address: 4202 Main Street, Philadelphia, Pennsylvania 19127
Telephone: (215) 487-1202

The entire casting, rolling, and wire drawing systems are scrutinized for tribological causes of wear, friction, and lack of lubrication.

Attention is paid to monitoring metallic constituents and "chips" in the emulsions, oils, sludges, and filter media.

Evaluations are leading towards better seal technology, diligent monitoring of possible lube or hydraulic leaks into a system, attention to lubricant and grease recommendations, changing fluid pressure and other engineering aspects of the entire casting and drawing systems.

Research plus application of tribological answers from the ferrous industry will lead to the formulation of nonferrous lubricants designed for maximum lubrication and extended solution life.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED: [✓ 1. Friction] [✓ 2. Wear] [✓ 3. Lubrication] [✓ 4. Surface Damage] 5. Failure 6. Fretting 7. Erosion [✓ 8. Adhesion] [✓ 9. Abrasion] 10. Fatigue 11. Load Capacity 12. Surface Temperature 13. Contact Stress 14. Film Formation [✓ 15. Oil Analysis] 16. Life [✓ 17. Filtration] 18. Noise 19. Leakage 20. Other (Please Specify)	TYPE OF MOTION: 1. Sliding [✓ 2. Rolling] 3. Slide/Roll 4. Impact 5. Reciprocating 6. Oscillating 7. Other (Please Specify)
VARIABLES CONSIDERED: [✓ 1. Load/Pressure] 2. Velocity 3. Temperature 4. Environment 5. Dist/Time/Amp [✓ 6. Geometry] 7. Finish/Lay 8. Composition 9. Structure 10. Physical Properties 11. Thermal Properties 12. Chemical Properties 13. Other (Please Specify)	LUBRICATION: 1. Unlubricated [✓ 2. Liquid Lubrication] 3. Gas Lubrication [✓ 4. Grease Lubrication] 5. Solid Lubrication 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: PROCESS TRIBOLOGY

Name: OWEN RICHMOND
Affiliation:
Address: ALCOA TECHNICAL CENTER ; ALCOA, PA 15069
Telephone: (412) 337-2998

Goals are to improve understanding of tribology in casting and deformation processes so as to improve process efficiency and control as well as product quality, both interior and surface.

Methods include experimental observations and mathematical modeling at macromechanical (variation of friction coefficients within contact region) and micromechanical (interactions of asperities, lubricants) and microstructural (subsurface grain and phase structure) levels.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

- [✓ 1. Friction]
- [✓ 2. Wear]
- [✓ 3. Lubrication]
- [✓ 4. Surface Damage]
- 5. Failure
- 6. Fretting
- 7. Erosion
- [✓ 8. Adhesion]
- 9. Abrasion
- 10. Fatigue
- [✓ 11. Load Capacity]
- [✓ 12. Surface Temperature]
- [✓ 13. Contact Stress]
- 14. Film Formation
- 15. Oil Analysis
- 16. Life
- 17. Filtration
- 18. Noise
- 19. Leakage
- 20. Other (Please Specify)

TYPE OF MOTION:

- [✓ 1. Sliding]
- 2. Rolling
- 3. Slide/Roll
- 4. Impact
- 5. Reciprocating
- 6. Oscillating
- 7. Other (Please Specify)

VARIABLES CONSIDERED:

- [✓ 1. Load/Pressure]
- [✓ 2. Velocity]
- [✓ 3. Temperature]
- 4. Environment
- 5. Dist/Time/Amp
- [✓ 6. Geometry]
- 7. Finish/Lay
- [✓ 8. Composition]
- [✓ 9. Structure]
- [✓ 10. Physical Properties]
- [✓ 11. Thermal Properties]
- [✓ 12. Chemical Properties]
- 13. Other (Please Specify)

LUBRICATION:

- [✓ 1. Unlubricated]
- [✓ 2. Liquid Lubrication]
- 3. Gas Lubrication
- 4. Grease Lubrication
- [✓ 5. Solid Lubrication]
- 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Bearing-Structure Interaction with Finite Element Methods

Name: Keith Rouch
Affiliation: University of Kentucky
Mechanical Engineering
Address: 242 Anderson Hall, Lexington, KY 40506
Telephone: (606) 257-8733

This project is in the planning stage. It addresses a need for methods to integrate the solution of equations representing the fluid film with those representing the structures comprising the bearing surfaces, to allow solution of the combined bearing-structure problem. Such a capability would allow improved design techniques for large bearings or those with non-rigid structures. The finite element approach is being explored.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. [✓ Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. [✓ Load Capacity]
12. Surface Temperature
13. Contact Stress
14. [✓ Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. [✓ Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. [✓ Load/Pressure]
2. [✓ Velocity]
3. [✓ Temperature]
4. Environment
5. Dist/Time/Amp
6. [✓ Geometry]
7. Finish/Lay
8. Composition
9. [✓ Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. [✓ Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

SURVEY TO ASSESS THE CURRENT LEVEL OF TRIBOLOGY RESEARCH AND DEVELOPMENT ACTIVITIES IN THE UNITED STATES

Name: JOHN E. SAGUE
Address:
Telephone Number: (215) 342-5084

Affiliation:
J. E. Sague & Associates
Bearing and Bearing System Engineers
P O Box No. 24653
Philadelphia, Pa. 19111
(215) 342-5084

We are involved in several projects to determine the probable reason/s for the premature failure of large diameter rotating equiptment and systems.

Several modes of failure are always present. These failure modes must be deleniated to determine which one was of first order or primary and all others, therefore, second order or after the fact of the primary failure mode. Analytical (computer anyalyses) as well as physical (metallographic and Scanning Eletron Microscophy) are utilized. Studies of the contact surface is often crucial.

A better knowledge of the forces and direction of forces of the rolling elements in these large diameter systems is needed.

Better understanding of lubricant required to protect wear surfaces when slide/roll phenomenm is present is needed.

(Please Circle All Appropriate Parameters)

All Circled But Crossed -out

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
~~12.~~ Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
~~17.~~ Filtration
~~18.~~ Noise
~~19.~~ Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

all of above

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
~~5.~~ Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
~~11.~~ Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

~~1.~~ Unlubricated
2. Liquid Lubrication
~~3.~~ Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Metallurgical and Tribological Effects of Ultrahigh Current Density Ion Implantation

Name: W. S. Sampath
Affiliation: Colorado State University
Address: Mechanical Engineering Department, Ft. Collins, CO 80523
Telephone: 303/491-5450

Samples that are ion implanted at current densities ranging to 2000 µA/cm^2 in a new broad beam (10 cm dia) implanter developed from ion rocket technology are being compared to samples implanted at the low current densities (10 µA/cm^2) characteristic of conventional implanters. The goal of this effort is order of magnitude reductions in the ion implantation processing times and associated costs coupled with improved tribological surface characteristics and no degradation of subsurface properties. The effects of heat sinking the samples on the time-temperature history of their surface during implantation are being considered in the study. Recent findings indicate that ultrahigh current density implantation (1) dramatically increases the ion penetration below the surface ($>$fourfold deeper than that observed at conventional current densities) and (2) induces no tempering/annealing in the bulk (beneath implanted zone) microstructure because of the very short implantation times required at ultrahigh current densities. Wear and friction testing and metallurgical examination of the implanted surfaces to demonstrate differences in the quality of the treated layer induced by ultrahigh current density processing are also being pursued.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)] Ion Implantation

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Surface Slip Retardation Induced by Ion Implantation

Name: W. S. Sampath
Affiliation: Colorado State University
Address: Department of Mechanical Engineering, Ft. Collins, CO 80523
Telephone: 303-491-5450

Ion implantation creates surfaces with defects (substitutional and interstitials) and precipitates. Dislocation motion is hindered in the implanted surface layer due to the mechanisms of solution hardening, defect interaction and precipitation hardening. A new test has been developed to study slip retardation on the surfaces of implanted samples. In this test, the specimens are annealed and selected regions of the etched surface are implanted. When the specimens are deformed, slip lines are observed in the unimplanted region and no slip lines are seen in the implanted region. This effect has been observed in α-Fe, 304 stainles steel and copper.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)] Ion Implantation

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
[✓ 7. Other (Please Specify)] Tension

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Analysis of Fluid Flow in Grinding

Name: William Schultz
Affiliation: Univ. of Michigan
Address: 2250 G. G. Brown, Ann Arbor, MI 48109-2125
Telephone: (313) 936-0351

Funded by GMotors APMES

Experimental and analytical study of the effect of different lubricants on the grinding process, and how they effect surface finish, wheel wear and the like. We have derived a higher-order correction to the Reynolds lubrication equation including inertia. We are presently trying to validate this equation for "smooth" grinding wheels by comparing flow rates and pressures

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: BRAKE NOISE

Name: Harlow W. Schwartz
Affiliation: Allied Signal, Bendix, FMD
Address: P. O. Box 238, Troy, New York 12181
Telephone: (518) 273-6550

GOAL -- Develop experimental noise evaluation techniques and identify correlation of the frictional and physical characteristics of friction materials to the propensity of noise generation due to sliding contact of brake components during operation.

APPROACH -- Conduct tests on vehicles, brake dynamometers and brake components. Use multi-channel spectrum analyzers, variety of dynamic transducers and modal analysis to study the acoustic and vibration characteristics of the brakes.

RECENT FINDINGS -- Brake noise frequencies generally match some of the natural frequencies of the brake components and the brake noise frequencies are independent of sliding velocities.

FUTURE DIRECTIONS -- Investigate relationships of brake noise frequencies with the dynamic characteristics of the applied pressure and brake torque parameters.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Low-Temperature Pumpability of Engine Oils

Name: Theodore W. Selby
Affiliation: Savant, Inc.
Address: 234 E. Larkin St., Midland, MI 48640
Telephone: 517-631-6050

Goal: Find a Correlative Bench Test for Engine Oil Pumpability

Approach: Generate low-temperature engine simulation information, there further develop corresponding bench technique.

Recent Findings: A so-called Scanning Brookfield technique coupled with a programmable low-temperature both shows

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DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Surface Adherence & Conformation of Oil Additives at Very High Shear Rates

Name: Thoedore W. Selby
Affiliation: Savant, Inc.
Address: 234 E. Larkin St., Midland, MI 48640
Telephone: 517-631-6050

Goal: Study adherence and influence of additives in lubricants at high rates of shear and close profinity of shearing surfaces

Method: Use TBS Viscometer at absolute gaps of 0.5 to 3.5 microns between rotor and stator. Vary temperature of surfaces

Findings: Initial work on surface adsorbed layers shows discontinuity in reciprocal torque/gap interrelationship

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Very High Shear Rate Viscometry

Name: Theodore W. Selby Affiliation: Savant, Inc.
Address: 234 E. Larkin St., Midland, MI 48640
Telephone: 517-631-6050

Goals: Continue development of the very high shear rate absolute viscometer (TBS Viscometer)

Approach & Findings: Using reciprocal torque

a) found that instrument is absolute (viscosity can be calculated from known torque and gap between tapered rotor and stator)

b) found that shear rate can be readily determined at the temperature of operation

Future: develop information in the ultra high shear rate region up to 10^7 sec^{-1}

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Low-Shear, High-Temperature Viscometry

Name: Theodore W. Selby Affiliation: Savant, Inc.
Address: 234 E. Larkin St., Midland, MI 48640
Telephone: 517-631-6050

Goals: Develop low-shear, high-temperature viscometry for comparison of temporary viscosity loss of polymer-modified lubricants.

Method: Use Brookfield viscometer and Thermocell to establish technique.

Findings: Equipment needs redesign but repeatability of viscometric measurement and temperature control of sample is excellent.

Future: Establish Test Method and automate.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tribology and Corrosion

Name: S. G. Seshadri
Affiliation: Standard Oil Engineered Materials Co
Address: P. O. Box 832, Niagara Falls, NY 14302
Telephone: (716) 278-6034/6103

Goals

Evaluate tribological behavior of Advanced Ceramics and composites and correlate to their microstructure, composition and mechanical properties.

Experimental Set-up

Ring-on-ring and pin-on-disc methods are used at room temperature with varying loads and speeds and the wear and friction performance of different materials are compared. This work has resulted in an extensive data base and some standard surface preparation techniques for ceramic seals. Further work at high temperatures is planned in the coming years.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
[✓ 7. Erosion]
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

PREVIOUS

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

PREVIOUS

Name: John J. Shatynski
Address: 347 Princeton Ave., Hillside, NJ 07205
Telephone: (201) 688-8276

Affiliation: Consultant (Retired)
CELANESE CORP.
STAUFFER CHEMICAL CO.

DEVELOPMENT, TESTING & MARKETING OF SYNTHETIC LUBRICANTS.

APPLICATIONS — LUBRICANTS FOR:

JET ENGINES
GASOLINE & DIESEL ENGINES
AIR COMPRESSORS
STEAM TURBINE CONTROL SYSTEMS
AIRCRAFT HYDRAULIC SYSTEMS
(BOTH HIGH TEMPERATURE & FIRE-RESISTANT LUBRICANTS)

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: M. C. Shaw
Affiliation: Arizona State University
Address: Tempe, AZ 85287
Telephone: (602) 965-3688

① Fundamentals of chipping and fracture of Tools.

② Wear ~~and~~ and performance of
Diamond/Ceramic - Rock - Metal Systems
CBN / Ferrous alloy, HT alloy Systems.

③ Soft Continuously replacable metal Coatings.

④ Mechanical Behavior of rubber under Combined States of stress.

⑤ Dynamometer design & performance

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4 Surface Damage]
[✓ 5. Failure]
6 Fretting
[✓ 7. Erosion]
[✓ 8. Adhesion]
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20 Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
[✓ 13. Other (Please Specify)]

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
[✓ 5. Solid Lubrication]
[✓ 6. Other (Please Specify)]

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: FUNCTIONAL REQUIREMENTS & SPECIFICATIONS OF TRIBOLOGICAL SURFACES

Name: CHI-HUNG SHEN
Affiliation: GENERAL MOTORS CORPORATION
Address: MD-A-03, GM TECHNICAL CENTER, WARREN, MI. 48090
Telephone: 313-947-0682

OBJECTIVES: Define and refine automotive tribological surface specifications to improve their manufacturing processes in areas of quality and production rates. The most important component surfaces are engine cylinder bores, camlobes, pistons, and transmission shaft and gear surfaces.

APPROACH: Manufacture components with different processes and different surface characteristics and evaluate the actual performance capabilities.

STATUS: Current emphasis on cylinder bores and transmission components.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: PROCESS TRIBOLOGY

Name: Shen Sheu
Affiliation: ASME
Address: ALCOA LABORATORIES
Telephone: ALCOA CENTER, PA 15069
(412) 337-2504

a) Characterize friction in all metal forming processes

b) Experimental and numerical analysis

c) surface finish as function of lubrication conditions

d) Control lubrication system in metal forming process

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
[✓ 7. Erosion]
[✓ 8. Adhesion]
[✓ 9. Abrasion]
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

SURVEY TO ASSESS THE CURRENT LEVEL OF TRIBOLOGY RESEARCH AND DEVELOPMENT ACTIVITIES IN THE UNITED STATES

Name: KEITH D. SHIELDS
Address: 3074 RESEARCH PARK DR.
ANN ARBOR, MI 48108
Telephone Number: (313) 761-4216

Affiliation: FEDERAL MOGUL CORP.
SENIOR RESEARCH CHEMIST
MATERIALS DEVELOPMENT

Is Tribology your main area of activity? ________ Yes __X__ No
If NO, please identify your main area of activity. R & D - ELASTOMERIC SEALING DEVICES
COMPOUND DEVELOPMENT

(Please Circle All Appropriate Answers)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name:
Address:
Telephone:

Affiliation:

WE ARE CURRENTLY EVALUATING VARIOUS ELASTOMER/COMPOUND COMBINATIONS TO MINIMIZE FRICTION, WEAR AND ABRASION ON OUR SHAFT SEALS.

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Solid Lubricated Ball/Cage Contact Simulation

Name: Lewis B. Sibley
Affiliation: Tribology Consultants, Inc.
Address: 504 Foxwood Lane, Paoli, PA 19301
Telephone: (215) 644 0481 or 648 0234

A special test fixture was fitted to an existing test machine recently adapted for testing steel balls between two rolling disks. Using this fixture, a test technique has been developed to measure the friction, transfer film rate, cage wear rate, and ball/race track surface damage and wear with several candidate solid lubricant materials and both steel and ceramic balls. These measurements are being coordinated with computer studies of ball/cage interactions in angular contact ball bearings for refinement of both the analyses and the measurement techniques. Then we plan to modify the test rig to operate at high speed and temperature, and develop improved design criteria for solid lubricated ceramic bearings. This improved engineering base for solid lubricated bearings will open up many more applications where the advantages of reduced maintenance and higher operating temperatures and speeds greatly simplify and improve the performance of many types of machinery using bearings. Also, the reliability of machinery will be improved as well as the competitive advantage of American industry in international markets with such technologically advanced products.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: H. R. SIGNER
Address:
Telephone: (213) 537-3750

Affiliation: INDUSTRIAL TECTONICS, INC.
18301 SANTA FE AVE.
RANCHO DOMINGUEZ, CA 90224

ROLLING CONTACT BEARING TESTS TO DETERMINE OPERATING CHARACTERISTICS AND/OR LIFE IN ENVIRONMENTS OF ADVANCED OR CRITICAL APPLICATIONS.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1 Friction]
[✓ 2 Wear]
[✓ 3 Lubrication]
[✓ 4 Surface Damage]
[✓ 5 Failure]
[✓ 6 Fretting]
7 Erosion
8 Adhesion
9 Abrasion
[✓ 10 Fatigue]
[✓ 11 Load Capacity]
[✓ 12 Surface Temperature]
[✓ 13 Contact Stress]
14 Film Formation
15 Oil Analysis
[✓ 16 Life]
17 Filtration
18 Noise
19 Leakage
20 Other (Please Specify)

TYPE OF MOTION

1 Sliding
[✓ 2 Rolling]
[✓ 3 Slide/Roll]
4 Impact
5 Reciprocating
6 Oscillating
7 Other (Please Specify)

VARIABLES CONSIDERED

[✓ 1 Load/Pressure]
[✓ 2 Velocity]
[✓ 3 Temperature]
[✓ 4 Environment]
[✓ 5 Dist/Time/Amp]
[✓ 6 Geometry]
[✓ 7 Finish/Lay]
8 Composition
9 Structure
[✓ 10 Physical Properties]
[✓ 11 Thermal Properties]
12 Chemical Properties
13 Other (Please Specify)

LUBRICATION

[✓ 1 Unlubricated]
[✓ 2 Liquid Lubrication]
3 Gas Lubrication
[✓ 4 Grease Lubrication]
[✓ 5 Solid Lubrication]
6 Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Nanometer Wear Measurement by Ultra-Thin Surface Layer Activation - NSF: ISI-8600917

Name: C. Blatchley
Affiliation: Spire Corporation
Address: Patriots Park, Bedford, MA 01730
Telephone: (617) 275-6000 X274

The goal of this project is to apply the surface layer activation (SLA) technique to measurements of wear or corrosion which are at least two orders of magnitude more precise than any previous applications. The specific system requiring this level of precision is a magnetic disk recorder which is sensitive to small amounts of surface damage in the recording medium. Several alternative methods of activating radionuclide markers in the recording material are being studied to determine if they can be used to produce activity distributions with the necessary characteristics for measurements in the nanometer range.

The preliminary results of these tests lead to the conclusion that producing ultra-shallow activation profiles is not as difficult as was originally expected. Several of the proposed activation methods are therefore quite feasible. The thin film and recoil implantation methods in particular may produce a significant reduction in cost over direct particle beam bombardment. Further tests are currently in progress to prove that these activation methods are sufficiently reproducible and predictable to allow reliable measurements in the nanometer range. To accomplish this, methods for precisely measuring the concentration of activity as a function of depth are being developed and tested.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: • HIGH TEMP TRIBOMATERIALS
• LUBRICATION OF CERAMICS

Name: H. SLINEY
Affiliation:
Address: MS 23-2 NASA, LeRC
21000 BROOKPARK RD CLEVELAND OH. 44135
Telephone:
216 433 6055
8 297 6055

GENERAL OBJECTIVE IS TO DEVELOP HIGH-TEMP, SELF-LUBR. MAT'LS FOR CERAMICS AND FOR HIGH TEMP. METALLIC ALLOYS. A COROLLARY GOAL IS TO ACHIEVE WIDE TEMP. RANGE OF USEFULNESS EXTENDING FROM ROOM TEMP. OR LOWER TO 1000°C.

PURPOSE IS TO PROVIDE LONG LIFE TRIBOMATERIALS FOR AEROSPACE APPLICATIONS AND FOR ENERGY-EFFICIENT TERRESTRIAL ENGINES.

A FUNDAMENTAL ASPECT OF THIS RESEARCH IS TO INVESTIGATE THE INFLUENCE OF PLASTIC SHEAR PROPERTIES OF FILMS & COATINGS ON THEIR TRIBOLOGICAL BEHAVIOR. ANOTHER IS THE GENERATION & CHARACTERIZATION OF CHEMICALLY-MODIFIED SURFICIAL LAYERS AND TO COMPARE THEIR TRIBOLOGICAL BEHAVIOR TO COATINGS.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
[✓ 3. Gas Lubrication]
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Low Heat Rejection Advanced HDD Engines

Name: Ralph Stone
Address: Box 3005
Telephone: 812-377-7527

Affiliation: Cummins Engine

Develop an air cooled or minimum water cooled Heavy duty diesel that will provide the following Benefits:

- Very low heat rejection
- Improved fuel economy
- Improved life
- Smaller heat exchangers (radiators, aircoolers etc)
- Reduced complexity

Have already been able to operate LHR engine without water cooling for extended test lengths. Have developed high temperature liquid lubs in conjunction w/ Stauffer Chemical to allow engine operation to 800°F TRR. Temperatures.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
[✓ 7. Erosion]
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
11. Load Capacity
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Ion Beam Modification of Ceramics to Enhance Their High Temperature Tribological Properties

Name: Frederick W. Smith
Affiliation: Colorado State University
Address: Engineering Research Center, Fort Collins, CO 80523
Telephone: 303-491-8657

Improvements in the high temperature wear and friction properties of ceramics are needed to make them suitable for use as moving parts in high performance engines. Ion mixing of metal films that form low melting temperature eutectic oxide layers at the ceramic surface are being studied as a means of achieving these improvements. Recent research has indicated that it is possible to use ion mixing of ceramics to reduce their high temperature (800°C) coefficient of friction to values characteristic of liquid (oil) lubricated metals at much lower temperatures.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1 Friction]
[✓ 2 Wear]
[✓ 3 Lubrication]
4 Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10 Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14 Film Formation
15 Oil Analysis
16 Life
17 Filtration
18 Noise
19 Leakage
[✓ 20 Other (Please Specify)] Ion Implantation

TYPE OF MOTION:

[✓ 1 Sliding]
2 Rolling
3. Slide/Roll
4 Impact
5 Reciprocating
6 Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED

[✓ 1 Load/Pressure]
[✓ 2 Velocity]
3 Temperature
4 Environment
5. Dist/Time/Amp
6 Geometry
7 Finish/Lay
8 Composition
9 Structure
10 Physical Properties
11 Thermal Properties
12 Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1 Unlubricated]
2 Liquid Lubrication
3 Gas Lubrication
4 Grease Lubrication
5 Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: UNDERSTANDING OF LUBRICANTION MECHANISMS IN THE DRAWING AND STAMPING OF SHEET STEEL.

Name: Mark K. Smith
Affiliation: PARKER CHEMICAL COMPANY
Address: 32100 Stephenson Highway, Madison Heights, MI 48071
Telephone: (313) 589-4624

We are using test equipment to quantify boundary and mixed film performance with various tool/material/lubricant combinations. Data is then correlated with actual metal stamping performance as measured by formability analysis techniques.

GOALS ARE: Determination of lubrication requirements for specific deformation modes, effect of the "friction variable" in the die development process, and improved tests for determination of a lubricant's performance. Recent findings are too premature for publication, however, good correlation and predictability has been obtained by using the concept.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
16. Life
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Determination of the Relationship Between Elastohydrodynamic Film Thickness Lubricants and the Magnitude of the Ultrasonic Waves Emitted Through the Bearing Material in a Rolling Element Bearing During Operation

Name: Eivind Søhoel
Affiliation: MILC CORPORATION
Address: 31 Old Marlborough Road, East Hampton, Connecticut 06424
Telephone: 203-267-0087

GOALS: Establishment of the calibration factor between the absolute EDH film thickness and the magnitude of the ultrasonic stress waves.

APPROACH: Refining and improving the use of the already patented SPM Method for the measurement of said stress waves, as well as applying this measuring method on operating test bearings together with other known methods for measurement of the EDH film thickness, such as the electric conductivity through the rolling contact.

FINDINGS: In accordance with the PATENT NUMBER 4,528,852, the existence of such a relationship is already proven.

DIRECTIONS: To be able, with reasonable accuracy, to measure the lubricant film thickness in an operating bearing during normal use in an industrial application.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

PROJECT TITLE: Power Circuit Breaker Mechanical Diagnositics

Name: Andres Soom* Affiliation: University at Buffalo
Address: Mech. and Aero. Eng.
Univ. at Buffalo
Buffalo, NY 14260
Telephone: 716-636-2734
*Co-principal investigator with: D. Benenson, T.T. Soong, Y. Lee and V. Demjanenko

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External vibration and acoustic signatures are being gathered from high voltage (121 kVAC and above) power circuit breakers during trip and close operations to assess their mechanical condition. The goal of the project is to develop measurement and analysis techniques that will identify abnormal or defective breakers without requiring internal visual inspection or disassembly. Known defects, introduced under laboratory conditions, are supplemented by field tests run in parallel with regular maintenence operations at power company sites. Techniques of dynamic modelling, short time signal processing, inverse filtering and pattern recognition are being applied to establish the diagnostic information necessary for decision-making. The circuit breakers are highly complex mechanical devices with numerous moving parts and bearing surfaces. The critical segments of close and trip operations only last for 200 to 300 milliseconds during which time a number of distinct events will occur. The external vibration and noise measurements, which must inevitably be taken at locations which are remote from the places where the faults of interest occur, are therefore heavily contaminated by resonant structural vibrations and extraneous noise. The results show that short time signal processing, in both time and frequency domains, followed by pattern recognition algorithms, provide a powerful method for distinguishing quite subtle differences among both the measured signatures and the underlying mechanical conditions. (Sponsor: Electric Power Research Institute).

VARIABLES CONSIDERED

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
7. Finish/Lay
8 Composition
9. Structure
[✓ 10 Physical Properties]
11 Thermal Properties
12 Chemical Properties
13 Other (Please Specify)

LUBRICATION

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Richard L. Spears
Address: P.O. Box 590
Telephone: Seminole, Oklahoma 74868
Affiliation: SurfGard, Division of TechniBlast Inc.

Commercializing a NASA patent involving application of solid lubricants by peen plating.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
[✓ 6. Fretting]
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: HARD COATING MATERIALS

Name: WILLIAM D. SPROUL
Affiliation: BORG-WARNER CORP.
Address: WOLF & ALGONQUIN RDS., DES PLAINES, IL 60018
Telephone:

DEVELOP HARD WEAR RESISTANT COATINGS FOR TRIBOLOGICAL APPLICATIONS.

REACTIVE SPUTTERING IS BEING USED TO PREPARE HARD COATINGS SUCH AS TiN, ZrN, HfN, TiC, ZrC, HfC, ETC.

THE HARD NITRIDES AND CARBIDES OF Ti, Zr, AND Hf ARE VERY EFFECTIVE IN EXTENDING THE LIFE OF CUTTING TOOLS.

FUTURE WORK WILL CONCENTRATE ON USING THE HARD COATINGS TO PREVENT WEAR ON ENGINEERING PARTS.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: TRIBOL 1000, 1100, 1200

Name: Phillip D Stapleton **Affiliation:** STAPLETON.
Address: 1350 W 17th.
Telephone: Long Beach. CA (213) 437-0541

We are developing Nickel and Cobalt based coatings for use in high temperature wear applications.

Three Systems are being studied.

1) Nickel, Cobalt, Thallium Boron. Coatings
2) Nickel Phosphorus, PTFE composite, Cobalt. phos
3) Nickel Phosphorus, SiC Composite.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
[✓ 6. Fretting]
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: PROGRAM 73R

Name: GERALD M. STEPHENS
Affiliation: W. S. DODGE OIL CO., INC.
(American Society of Lubrication Engineers)
Address: 3710 FRUITLAND AVE.
MAYWOOOD, CALIF. 90270-2196
Telephone: (213) 583-3478

WE ANTICIPATE A RESEARCH/DEVELOPMENTAL PROGRAM EMPHASIZING SOLID FILM/DRY FILM/SEMI-FLUID SURFACE IMPREGNATION OF COMMON AND EXOTIC ALLOYS FOR THE PURPOSE OF REDUCING FRICTION, FRETTING, WEAR. GOALS WILL INCLUDE THE REPLACEMENT OF CONVENTIONAL LIQUID PETROLEUM OR SYNTHETIC LUBRICANTS IN EXTREMELY HEAVY-DUTY SERVICE. THIS IS ANTICIPATED TO INCLUDE TRANSMISSION AND DIFFERENTIAL GEARING COMPONENTS, STATIONARY MACHINERY, WEAPONS SYSTEMS, SMALL ARMS AND OTHER MILITARY HARDWARE UNDER CONDITIONS IN WHICH THE ENVIRONMENT OR WORKING CONDITIONS PRODUCE EXTREMES OF TEMPERATURE/PRESSURE. IT IS ALSO HOPED TO REDUCE CONTAMINANTS ATTRACTED UNDER FIELD CONDITIONS TO CONVENTIONAL LIQUID LUBRICANT SYSTEMS, WITH THE AIM OF PROVIDING RELIABILITY TO FIELD ARMS/HARDWARE. GRANTS FOR THIS RESEARCH PROGRAM HAVE NOT BEEN APPLIED FOR.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
[✓ 6. Fretting]
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
[✓ 4. Impact]
[✓ 5. Reciprocating]
[✓ 6. Oscillating]
[✓ 7. Other (Please Specify)]

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)
UNDETERMINED

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: HIGH SPEED FRICTION

Name: A. Kent Stiffler
Affiliation: Mississippi State University
Address: Drawer ME, Mississippi State, MS 39762
Telephone: (601)325-3260

A melt concept is proposed to explain the tribology of unlubricated metal pin-on disk sliding at high speeds. A squeeze film model of the melt film is developed which depends on the continually forming melt to give steady-state load support. Expressions are derived for the film thickness, coefficient of friction, and wear. The theory is applied to pin-on-disk data available in the literature. There is good agreement between theory and experiment for the friction coefficient. The results for wear are inconclusive. A significant factor affecting the findings is surface roughness.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Gearbox wear

Name: Thomas J. Stiegowski
Affiliation: ASME
Address: 189 Patterson Way, Berlin, CT 06037
Telephone: (203) 828-3935

Analysis of different lubrications on extruder gear boxes. Evaluation includes review of gear wear and thrust bearing section. Variable include type of oil, temp, pressure, flow parameters and gear design.

Testing is ongoing and data will be collected for another 6 months

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
[✓ 15. Oil Analysis]
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: D. C. Sun
Affiliation: G. M. Research Laboratories
Address: Fluid Mechanics Dept., G.M. Research Labs, Warren, MI 48090
Telephone: (313) 986-0040

Currently involved in 4 projects:

1. Study of contact condition between the piston ring and cylinder bore. The study will eventually lead to the determination of ring bore friction
2. Hydrodynamic lubrication in sheet metal forming. The purpose of the project is the determination of interface friction between the punch and the sheet, thus providing the needed boundary condition for numerical simulation of sheet metal forming process.
3. Surface roughness effect in hydrodynamic lubrication. The specific goal of this project is to obtain numerical solutions of roughness effects bridging the gap between known solutions for the Reynolds roughness and the Stokes roughness.
4. Cavitation of oil ~~better~~ film in dynamically loaded journal bearings. The aim of the project is to develop better design packages for squeeze film dampers and IC engine bearings.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tribology and Sliding Wear

Name: Paul Swanson
Affiliation: Deere & Co. Technical Center
Address: 3300 River Drive, Moline, IL 61265
Telephone: (309)757-5270

Objective

Identify and develop appropriate wear testing, analysis, and prediction techniques that assist Deere factory units with the design, development, and manufacture of products with superior wear resistance.

Note: This broad-based objective is required because John Deere manufactures a wide variety of agricultural and industrial equipment. Consequently, the results of our tribology research activity at the Deere & Company Technical Center must be applied as widely as possible to ensure the optimum tribological performance of Deere's products. While working with specific factory units in solving problems related to wear, friction, and lubrication; a concerted effort is made to develop test, analysis, and prediction techniques that may be readily used by other Deere units with similar tribology concerns.

Current Work

Current work is focussed on the development of wear testing, analysis, and prediction techniques that can be used by Deere engineers in designing mechanical components in which rolling/sliding contacts occur under lubricated conditions. Some work is also being done on the mild/severe wear that takes place under dry sliding conditions.

Previous Results

Previous work focussed on understanding the mechanisms of abrasion that occurs on soil working tools. It was found that a laboratory abrasion test which uses a dry sand rubber wheel apparatus can adequately rank various heat treated steels, cast irons, and hardfacings according to their abrasion resistance. (See P. A. Swanson and R. W. Klann, "Abrasive wear studies using the wet sand and dry sand rubber wheel tests", In S.K. Ree, A.W. Ruff, and K.C. Ludema (eds), Wear of Materials, ASME, New York, 1981, pp. 379-389.) Also for a limited range of materials it was found that the results of this test correlated with those obtained in soil working tests carried out in a sandy soil. (See P. A. Swanson, "Comparison of laboratory and field abrasion tests", In K.C. ludema (ed), Wear of Materials, ASME, New York, 1985, pp.519-525.)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: ——

Name: William A. Swarts
Affiliation: Royal Lubricants Co.
Address: Box 518, E. Hanover, N.J. 07936
Telephone: 201-887-7410

Main efforts are devoted to synthesis of base oils for jet turbine oils and hydraulic fluids. Secondary objectives are synthesis of specialty additives, improving additive packages for both conventional and experimental oils and hydraulic fluids, manufacturing plant support and minimization and removal of all wastes. I am also deeply involved in safety - looking at procedures, equipment, clothing, toxicity of raw materials, etc.

Syntheses are generally straightforward, taken directly from or easily adapted from, open literature. Blending work is directed toward improving product stability. Plant support work heavy recently.

Future work will be more deeply involved with plant support, but overall goals will be unchanged.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
[✓ 6. Other (Please Specify)]
Additive effects

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: J. MICHAEL GAFFNEY Affiliation: W. L. SUMNER INC.
Address: 10014 VALLEY FORGE, HOUSTON TX 77042
Telephone: 713-932-7663

DESIGN & DEVELOPMENT OF BRONZE & TRI-METAL BUSHINGS FOR PISTON PINS ON 2-CYCLE COMPRESSORS & BUSHINGS FOR CROSSHEAD PINS ON RECIPROCATING GAS COMPRESSORS

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Effect of Convective Inertia on Bearing Performance

Name: Andras S. Szeri Affiliation:
Address: Department of Mehanical Engineering, Univ. of Pittsburgh, Pittsburgh, PA 15261
Telephone: (412) 624-5338

In this numerical study of fluid inertia effects in long journal bearings, we compare results from (1) the full Navier-Stokes equations, (2) a lubrication approximation relative to the natural, i.e., the bipolar coordinate system, and (3) the Reynolds lubrication approximation. The study indicates that in the range $0 < Re < 2000$, where $Re = R\omega C/\nu$ is the Reynolds number, incorporation of convective fluid inertia changes the magnitude of lubricant force and linearized oil film stiffness at most in the third significant digit for typical bearing geometries, in comparison with non-inertial values of the same quantities.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Behaviour of Viscoelastic Lubricants in High Shear Rate.

Name: Andras S. Szeri Affiliation:
Address: Department of Mechanical Engineering, Univ. of Pittsburgh, Pittsburgh, PA 15261
Telephone: (412) 624-5338

In bearings of various types non-Newtonian effects might assume importance due mainly to two circumstances: process fluid lubrication and treatment of the lubricant with polymeric additives. Yet there is little available in the way of material characterization of lubricants. In this experimental/numerical research we study the behaviour of viscoelastic fluids under high rate of shear. The apparatus is rotating parallel discs (prototype of flow in a thrust bearing). A marked departure in the flow characteristics of the non-Newtonian fluid under consideration from that of the Newtonian fluid is the appearance of a narrow layer where in the velocity gradients are exceedingly hight. The numerical method utilizes bifurcation theory - to locate point of instability - and spectral methods. The theoretical model we are presently using is that of Oldroyd - B fluid.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED.

1. Load/Pressure
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
[✓ 6. Other (Please Specify)] VISCOELASTIC FLUID

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Thermohydrodynamic Performance of Journal Bearings with Non-Newtonian Lubricants.

Name: Andras S. Szeri
Affiliation:
Address: 649 Benedum Hall
Telephone: (412)624-5338

This research is aimed at investigating the performance of journal bearings under non-isothermal conditions, when operated with non-Newtonian lubricants. Our reasons for undertaking this research are as follows: Calculations based on Newtonian lubricant behavior predict what sometimes is a serious degredation of bearing performance, due to the temperature caused changes in lubricant viscosity. On the basis of our recent investigations into Poiseuille flow between parallel plates we, on the other hand, suggest it possible that even slight departure from Newtonian behaviour of the lubricant renders bearing performance relatively insensitive to changes in lubricant temperature. To demonstrate the validity of our contention we evaluate the performance of bearings operating with non-Newtonian lubricants. We do this in the correct manner, i.e. through a thermodynamic analysis that is appropriate to non-Newtonian fluids. Finite difference and spectral methods are used in the analysis.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED: 1. Friction 2. Wear 3. Lubrication 4. Surface Damage 5. Failure 6. Fretting 7. Erosion 8. Adhesion 9. Abrasion 10. Fatigue 11. Load Capacity 12. Surface Temperature 13. Contact Stress 14. Film Formation 15. Oil Analysis 16. Life 17. Filtration 18. Noise 19. Leakage 20. Other (Please Specify)	TYPE OF MOTION: 1. Sliding 2. Rolling 3. Slide/Roll 4. Impact 5. Reciprocating 6. Oscillating 7. Other (Please Specify)
VARIABLES CONSIDERED: 1. Load/Pressure 2. Velocity 3. Temperature 4. Environment 5. Dist/Time/Amp 6. Geometry 7. Finish/Lay 8. Composition 9. Structure 10. Physical Properties 11. Thermal Properties 12. Chemical Properties 13. Other (Please Specify)	LUBRICATION: 1. Unlubricated 2. Liquid Lubrication 3. Gas Lubrication 4. Grease Lubrication 5. Solid Lubrication 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Stability of Flow Between Rotating Eccentric Cylinders.

Name: Andras Z. Szeri
Affiliation:
Address: Dept. of Mechanical Engineering, Univ. of Pittsburgh, Pittsburgh, PA 15261
Telephone: (412) 624-5338

It is essential for the designer of large rotating apparatus to know apriori the operating conditions his machine will experience. But the prediction of operating flow regime cannot be based on the isothermal theory. Isothermal theory predicts flow transition in the local Reynolds number range $1500 < R_h < 2000$, in contradistinction to the range found in large bearings, VIZ., $400 < R_h < 800$. In this numerical study of flow between eccentric rotating cylinders we use bifurcation theory to locate the conditions where the basic flow gives up its stability. The full Navier-Stokes equations are solved by spectral method and the bifurcation point is located using pseudo arclength continuation. The computations are performed on the CRAY X-MP of the Pittsburgh Supercomputing Center.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)] STABILITY, TRANSITION

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Tibor E. Tallian
Affiliation: Tallian Consulting Corp.
Address: 36 Dunminning Road
Newtown Square, PA 19073
Telephone: 215 688-4552

Hertzian contact fatigue life prediction models. Corrections for environmental and design parameters. Formulation suitable for computer programming use. Plan: Include fatigue limit stress in model.

Rolling bearing failurediagn osis expert systems. Plan: continue.

Tribology database user interface expert system concept design. Plan: seek sponsorship.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: FRICTION AND WEAR OF CERAMIC MATERIALS

Name: Gerald J. Tennenhouse
Address: P.O. Box 2053, S-2079
Dearborn, Michigan 48121
Telephone: 313-594-0982

Affiliation: Scientific Research Laboratory
Ford Motor Co.

1. Investigate the interactions of ceramic cutting tool materials such as silicon nitride and tungsten carbide with common metals such as cast iron and steel under the speeds, loads , and enviornments of machining conditions. Both pin on disk wear tests and actual machining tests were used. Chemical contributions to wear were identified and methods of inhibiting interfacial chemical reactions were developed, resulting in reduced wear.

2. Investigate the friction and wear of ceramic materials under conditions of speed, load, enviornment, temperature and relative motion (reciprocating & continuous), similar to those of high temperature heat engines in the absence of conventional lubrication. This work is presently in progress. The major method of approach is by pin on disk tests under controlled conditions. Some unexpected wear mechanisms and some novel approaches to friction and wear reduction have been identified. However, this work is proprietary at the present time.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
[✓ 7. Erosion]
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
[✓ 3. Gas Lubrication]
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: ROBERT G. THOMPSON Affiliation: DECK MANUFACTURING CORP
Address: 51477 BITTERSWEET RD.
Telephone: GRANGER, INDIANA 46530

GALLING OF INTERFERENCE FIT HUBS AND SHAFTS OF INCONEL AND COATED INCONEL

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
[✓ 13. Contact Stress]
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
[✓ 7. Other (Please Specify)]

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

1) PROJECT TITLE: "Improvement to Lubrication Theory in High Speed Machinery due to Fluid Inertia and Viscoelasticity"

Name: John A. Tichy
Affiliation: Rensselear Poly. Inst.
Address: Mech. Eng. Dept., RPI, Troy NY 12181
Telephone: 518-266-6986

Sponsor - NSF, Goal - develop improved theory with better predictive ability at high speeds. Classical theory inadequate to predict critical speeds, instability onset, etc., Approach - Analytical and Experimental, Recent Findings - simple expressions for stiffness, damping coefficients, Future Directions - experimental verification of "ram pressure" effect for sliding bearings.

2) "The Effect of Lubricant Inertia and Viscoelasticity in Squeeze Film Damper Bearings", sponsor - ARO, Goal - develop new models for SFD behavior Approach - Analytical/Exp., Recent Findings - new dynamic cavitation model, experimental verification, turbulence effect. Future Directions - experimental verification, turbulence effect.

3) "Monitor Condition of Bearings in Altair Antenna", sponsor - ~~GTE~~ Gov't Systems goal - prevent and/or predict onset of failure in very large, highly loaded REB's, Approach - ferrography and other diagnostic testing, Recent Findings - data base (of wear debris) can be established, Future Directions - continue, other bearings

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: John Lucek
Affiliation: Norton Co; High Performance Ceramics
Address: Goddard Road, Northboro, Ma. 01532
Telephone: 617-393-5821

GOALS

Processing Improvements of Silicon Nitride Ceramics for reduced cost

Processing Improvements of Silicon Nitride Ceramics for superior performance

Approach Simultaneous fatigue life and wear determination under highly load accelerated ~~[illegible]~~ ~~[illegible]~~ element tests.

RECENT FINDINGS Significant cost reductions possible; potential to produce ceramic at less than 10 times metal (M-50) cost.

FUTURE DIRECTIONS - REDUCE material susceptibility to processing flaws: scratches, subsurface distress, inclusions..

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
[✓ 10. Fatigue]
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tribology of Gas Lubricated ~~Valves~~ Micro-Valves

Name: Kris C. Tripathi
Affiliation: Foxboro Co
Address: N01-2A, Foxboro, MA 02035
Telephone: (617)-549-2920

This project was undertaken to recommend materials with good reliability for micro-valves in gas chromatograph where abrasion of the sliding surface ~~due to~~ is caused by sub-micron particles in petrochemical gases. The life of the valves is, therefore limited. A number of ceramic materials were considered for increasing the life. The studies provided an understanding of the mechanism of wear and of the initiating substep. A proprietary material was found most cost effective and substantially improved the life.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

- 1. Friction
- [✓ 2. Wear]
- 3. Lubrication
- [✓ 4. Surface Damage]
- 5. Failure
- 6. Fretting
- 7. Erosion
- 8. Adhesion
- [✓ 9. Abrasion]
- [✓ 10. Fatigue]
- 11. Load Capacity
- 12. Surface Temperature
- 13. Contact Stress
- 14. Film Formation
- 15. Oil Analysis
- 16. Life
- 17. Filtration
- 18. Noise
- 19. Leakage
- 20. Other (Please Specify)

TYPE OF MOTION:

- 1. Sliding
- 2. Rolling
- [✓ 3. Slide/Roll]
- 4. Impact
- 5. Reciprocating
- 6. Oscillating
- 7. Other (Please Specify)

VARIABLES CONSIDERED:

- 1. Load/Pressure
- 2. Velocity
- 3. Temperature
- 4. Environment
- 5. Dist/Time/Amp
- 6. Geometry
- 7. Finish/Lay
- 8. Composition
- 9. Structure
- [✓ 10. Physical Properties]
- 11. Thermal Properties
- 12. Chemical Properties
- [✓ 13. Other (Please Specify)] Life

LUBRICATION:

- 1. Unlubricated
- 2. Liquid Lubrication
- [✓ 3. Gas Lubrication]
- 4. Grease Lubrication
- 5. Solid Lubrication
- 6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Advanced Bearing & Damper Research

Name: DICK TRIPPETT
Affiliation: ALLISON GAS TURBINE
Address: POB 420 2001 S TIBBS W16 INDIANAPOLIS IND
Telephone: 317 242 3058

This program addresses critical technical problems that are limiting advanced rotor system designs. The major bearing problem caused by higher temperatures is the unavailability of oil as a bearing lubricant. The objectives of this program are to develop technologies to solve these bearing, damper, and rotor system problems to reliably design future high-temperature, high-speed shafting. All ceramic rolling-element bearings, gas bearings, and magnetic bearings are the candidates that are to be investigated as to their applicability to aircraft gas turbine engines.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: DRY THREAD MAKE UP

Name: W D VAN ARNAM
Affiliation: BAKER PACKERS
Address: PO BOX 3048 HOUSTON TX 77253
Telephone:

DEVELOP A DRY FILM SOLID, ION DEPOSITED WHICH WILL ALLOW FOR DRY (NO THREAD DOPE) MAKE UP OF API, API MODIFIED AND PROPRIETARY THREADS ON OILWELL TUBING AND CASING. FILM MUST BE NON REACTIVE WITH DOWNHOLE ENVIRONMENTS AND MUST NOT PROMOTE GALVANIC ATTACK OF THE SUBSTRATE.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: "High-Performance Damper Analysis & Test Program"

Name: John M Vance
Address: Mechanical Engineering
Telephone: (409) 845-1257
Affiliation: Texas A&M University
College Station, Tx 77843

This project is supported by GE Aircraft Engine Group, Cincinatti. The goal is to develop improved design and analysis tools for prediction of squeeze film damper forces. An instrumented test rig has been built and computer programs have been written. New theory has been developed and experimentally verified to include the effects of fluid inertia on damper forces.

Effects of turbulence have been analyzed and are now being investigated experimentally.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

Force coefficients for rotordynamic analysis

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

Two-phase

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: EXTENDED LIFE BRAKE LINING/STEEL PLATE FRICTION SYSTEM

Name: T. C. SEKELLA
Address:
Telephone:

Affiliation:

SEPAC, INC. IS A MANUFACTURER OF ELECTROMAGNETIC AND HYDRAULIC CLUTCHES AND BRAKES. THE DESIGNS OF THESE DEVICES ARE VARIED, BUT ALL INVOLVE APPLICATION OF TRIBOLOGY.

THE CURRENT PROJECT HAS AS AN OBJECTIVE THE EVALUATION AND CLASSIFICATION OF FRICTION MATERIALS AND THE MATING STEEL PLATE(S), PLUS THE RESEARCH INTO THE POSSIBLE EVALUATION OF NON-STANDARD FRICTION MATERIALS, SUCH AS CERAMICS AND CARBON/CARBON COMPOSITS, AND COATINGS ON THE STEEL. THE OBJECTIVE IS TO SELECT FRICTION SYSTEMS MORE EFFICIENTLY TO MEET CUSTOMER/APPLICATION REQUIREMENTS, WITH MINIMUM WEAR AND OR DISTORTION, MINIMUM ADVERSE HEALTH EFFECTS, AND MAXIMUM STABILITY OF PERFORMANCE WITHIN THE ECONOMIC BOUNDS OF THE MARKET.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
[✓ 18. Noise]
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Arthur F. Vetter
Address: Iowa City, IA 52242
Telephone: (319) 335-1413

Affiliation: University of Iowa
Chemical & Materials Engineering

The goals of the project are:

(1) To compare wear resistance of a broad spectrum of metals, alloys, polymers, and polymer composites using ASTM procedures G-65.

(2) To compare wear resistance of the above materials using other, non-ASTM specified abrasives.

(3) To study the size and shape parameters of both the abrasives used and the wear debris produced.

(4) To use the data produced in (1), (2), and (3) above to relate wear mechanisms to the abrasive environment, the test material, and the nature of the abrasive used.

(5) To develop a quantitative comprehensive theory of abrasive wear.

(6) To provide system designers with data for optimum material selection for a variety of applications.

The project has already produced abrasive data and wear debris data on a number of carbon steels. 4340 stainless steel and a group of selected polymers and polymer composites are currently being studied in goals (1) to (4) above.

Future directions will continue these studies with other materials including hard-faced and chrome plated steels and to pursue goals (5) and (6).

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
[✓ 7. Erosion]
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Fretting Wear

Name: Olof Vingsbo
Affiliation: University of Houston
Address: Mechanical Engineering Dept. 4800 Calhoun, Houston, Tx 77004
Telephone: 749-2448

Fretting phenomena are studied with the aid of specially built equipment, covering a range of displacement amplituded from sub-incipient slip to reciprocating sliding (1-200 μm) and vibration frequencies (10 - 20,000 Hz).

Experiments are carried out under both elastic and plastic contact conditions. The scope is to find relationships between fretting performance and materials parameters. The development and use of Fretting Maps is emphasized. The possibility of using Fretting Maps for predicting the fretting performance of a material under a given set of contact conditions is being explored. The relevance of accelerated fretting tests, using ultrasonic frequencies, will be considered.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
[✓ 6. Fretting]
7. Erosion
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
[✓ 5. Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Single Pass Pendulum Grooving

Name: Olof Vingsbo
Affiliation: University of Houston
Address: Mechanical Engineering Dept. 4800 Calhoun, Houston, Tx 77004
Telephone: 749-2448

The abrasion resistance of metallic materials is studied by single pass grooving with the aid of a so-called Uppsala Pendulum. The testing equipment consists of a Sharpy type impact pendulum, modified by having a cemented carbide tip protruding radially from the end of the hammerhead. During a pendulum's downswing the tip makes an accurate groove in a specimen, horizontally placed at the lowest part of the pendulum path. The energy loss E is found by taking a reading from the standard gauge of the pendulum. The corresponding weight loss W is found by weighing the specimen. The Specific Grooving Energy e = E/W is used as a measure of the abrasion resistance of the material. In particular, the dependence of e on the weight loss gives information of the abrasion resistance as function of the severity of the abrasion.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1 Friction]
[✓ 2 Wear]
3. Lubrication
4. Surface Damage
5 Failure
[✓ 6 Fretting]
7. Erosion
8 Adhesion
[✓ 9 Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17 Filtration
18 Noise
19. Leakage
20 Other (Please Specify)

TYPE OF MOTION:

[✓ 1 Sliding]
2. Rolling
3 Slide/Roll
4. Impact
[✓ 5 Reciprocating]
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED

[✓ 1 Load/Pressure]
[✓ 2 Velocity]
3 Temperature
[✓ 4 Environment]
[✓ 5 Dist/Time/Amp]
6 Geometry
7 Finish/Lay
[✓ 8 Composition]
[✓ 9 Structure]
10 Physical Properties
11 Thermal Properties
12 Chemical Properties
13 Other (Please Specify)

LUBRICATION

[✓ 1 Unlubricated]
2 Liquid Lubrication
3 Gas Lubrication
4 Grease Lubrication
5 Solid Lubrication
6 Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Surface Texture Measurement and Applications

Name: Theodore Vorburger
Affiliation: NBS
Address: A117, Metrology, Gaithersburg, MD 20899
Telephone: (301) 975-3493

Our goals are to explore the usefulness of surface texture measurement for a wide range of applications including tribology and to develop light scattering techniques for on-line inspection of surfaces in industrial applications.

Our methods include stylus techniques as well as light scattering.

We have recently succeeded in describing quantitatively the optical scattering patterns from rough surfaces by predicting them from stylus data. The results compare well with experiment.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: CP 601-20

Name: Douglas A. Wallace
Affiliation: Project Manager
Address: 6295 Crow Creek Road, Bettendorf, IA 52722
Telephone: (319) 332-8399

High solids lubricating grease/paste containing Copper matrix with encapsulated lead.

Evaluation of proprietary metalurgical lubricating solids, their compatability with other lubricating additives, reduction of wear, increased load carrying capabilities, reduction of Amp draw.

Laboratory results and empirical data evaluation.

Product now in use for one year, Europe and the U.S.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
[✓ 16. Life]
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/[✓ Amp]
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

Self lubricating Alloys

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: HYDRODYNAMIC LUBRICATION

Name: C Y WANG
Address: EAST LANSING MI
Telephone: 517 353 3537
Affiliation: MICH STATE UNIV

Sliding lubrication problems are solved analytically by perturbation methods.

REFERENCES:

"The forces due to the relative motion of two corrugated plates", Phys. Fluids, 26, 611-613, 1983.

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"The skidding of an elliptic plate on a wet surface", Appl. Sci. Res., 42, 201-209, 1985.

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(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
[✓ 7. Other (Please Specify)]

SQUEEZE FILM

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

SURVEY TO ASSESS THE CURRENT LEVEL OF TRIBOLOGY RESEARCH AND DEVELOPMENT ACTIVITIES IN THE UNITED STATES

Name: Dana Watts
Affiliation: Lubrication Engineer
Address: Armco Inc.,
1801 Crawford St. Middletown, Ohio
Telephone Number: (513) 425-6494
Telephone: (5' '- 0

My efforts are directed towards developing a comprehensive lubrication program in our steel plants that will achieve the optimum machine performance at the minimum cost. I do not research in the classical sense, I rather try to determine the best product for each application.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
[✓ 5. Failure]
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
[✓ 16. Life]
[✓ 17. Filtration]
18. Noise
[✓ 19. Leakage]
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
[✓ 4. Grease Lubrication]
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: WEAR RESISTANT MATERIALS

Name: S.-T. Buljan
Affiliation: GTE LABORATORIES
Address: 40 SYLVAN RD Waltham, MA. 02254
Telephone: 617-466-2816

Goals: Develop ceramic/composite materials for wear part applications and cutting tools.

Approach: Material Design criteria which incorporates mat'l mechanical properties, wear resistance, performance in lab tests and field applications.

findings: Ceramic composites are "Tailorable" in so far as measured mat'l properties can be used to predict performance in metal cutting applications based on microstructural considerations.

Future: Expand composite mat'l development beyond existi Si_3N_4 matrix; whisker dispersoids. Explore replacem binders for new cermets without cobalt.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED.

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
[✓ 7. Erosion]
8. Adhesion
[✓ 9. Abrasion]
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)] Chemical/Diffusion Solubility cutting tool wear

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED

1. Load/Pressure
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify) metal cutting coolants

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: EFFECT OF MOLD RELEASE LUBRICANTS ON THE SURFACE CHEMISTRY OF GLASS

Name: JAMES J. WERNER
Affiliation: SPECIALTY PRODUCTS CO
Address: 75 MONTGOMERY STREET JERSEY CITY N.J. 07303
Telephone: (201) 434-4700

WE WISH TO SEE THE EFFECTS OF COMPONENTS OF GLASS MOLD RELEASE LUBRICANTS ON THE SURFACE OF GLASS DURING THE MANUFACTURE & FORMING OF GLASS CONTAINER THIS IS TO OPTIMIZE THE TYPE OF LUBRICANT USED. WE WILL USE HIGH TEMPERATURE F.T. I.R. ANALYSIS TO STUDY THE GLASS SURFACE.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
9. Structure
10. Physical Properties
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Tribological and Mössbauer Studies of Ion-Implanted Iron and Steels

Name: Paul J. Wilbur
Affiliation: Colorado State University
Address: Mechanical Engineering Department, CSU
Fort Collins, CO 80523
Telephone: 303/491-8564

Research on simple metallurgical systems is being pursued to determine the mechanisms by which ion implantation and concurrent and post implantation heat treatment influence the wear behavior of these systems. Ion implantation of boron, carbon, and nitrogen into pure iron, iron carbide and into steels with simple metallurgical microstructures is being pursued. The ion implantation is being carried out over a range of current densities, doses and energies. The primary microstructural characterization of the surface modified layers before and after wear testing is being done in a nondestructive manner using unusual Mössbauer spectroscopy techniques. Supplementary analytical methods including Auger electron spectroscopy, x-ray photoelectron spectroscopy, and transmission electron microscopy are also being utilized. A dramatic increase in the load bearing capacity of stainless steel in lubricated sliding contact (> 40 times) has been induced by nitrogen ion implantation. Nitrides of chromium and iron detected by line shape analysis of Auger electron spectrographs have been found to accompany improved load bearing capacity. A 60% improvement in the wear resistance of 01 tool steel has also been found to accompany nitrogen ion implantation of this alloy.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)] Ion Implantation

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: 1. Sliding of Steel Under Pressure
2. Mueller Matrix Ellipsometry of Practical Surfaces

Name: Molly W. Williams
Affiliation:
Address: Mechanical Engineering Dept., Western Michigan University, Kalamazoo, MI 49008
Telephone: 616-383-4021

A film of Fe_3O_4 forms and grows on steel in dry sliding under both low pressure - long sliding distances and under high pressure - short sliding distances.

Ellipsometry is a valid technique for establishing film optical properties (and hence identity) and thickness.

Future directions: Mueller matrix ellipsometry will be used to establish a base of information relating ellipsometric parameters to surface finish for a variety of materials and surface finishing techniques. Ellipsometry has potential as a non-destructive method of detecting changes in surface profile and surface film composition and thickness.

It is anticipated that ellipsometry will be developed into a valuable technique to follow the changes in surface profile and film composition that take place during many wear and friction investigations.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3. Temperature
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
[✓ 7. Finish/Lay]
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Lubrication by Emulsions

Name: William R. D. Wilson
Affiliation: Northwestern University
Address: ME Dept., 2145 Sheridan Rd., Evanston, IL 60201
Telephone: (312) 491-7099

An analytical study of the film forming abilities of emulsions has been conducted. The analysis of lubrication by oil droplet patches surrounded by water shows an influence of concentration similar to that which has been observed experimentally. Work is in progress to build an experimental rig to try to visualize droplet flow and to measure film thickness by interferometry. It is hoped that the work will lead to a better theoretical understanding of lubrication by emulsions.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
[✓ 13. Other (Please Specify)]
CONCENTRATION

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
[✓ 6. Other (Please Specify)]
EMULSIONS

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Lubrication in Upsetting

Name: William R. D. Wilson
Affiliation: Northwestern University
Address: ME Dept., 2145 Sheridan Rd., Evanston, IL 60201
Telephone: (312) 491-7099

Experiments are being conducted using a computer-controlled press to upset (forge) aluminum bars with a variety of solid lubricants. Initial work centered on the influence of speed on film formation and friction. Very little effect of speed was found. Current work is dealing with the behavior of layered lubricant films and some preliminary theoretical models have been developed. It is hoped that this may lead to a better understanding of lubricating capabilities of lamellar solids like graphite as well as deliberately created layered coatings.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)
SQUEEZE & PLASTIC DEFORMATION

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
[✓ 9. Structure]
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
[✓ 13. Other (Please Specify)]
LUBRICANT LAYERS

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Lubrication in Strip Drawing

Name: William R. D. Wilson
Affiliation: Northwestern University
Address: ME Dept., 2145 Sheridan Rd., Evanston, IL 60201
Telephone: (312) 491-7099

Experiments are being conducted to better understand the influence of lubricant film thickness on friction and surface roughness in strip drawing with flat dies. Wax coatings and other solid lubricants are being used with the thickness controlled by varying die angle. A dynamometer is used to measure normal and tangential die forces. The research is aimed at developing better models for friction and topography changes in metal forming.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)]
ROUGHNESS CHANGES

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
[✓ 7. Other (Please Specify)]
PLASTIC DEFORMATION

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7. Finish/Lay]
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Lubrication in Stretch Forming

Name: William R. D. Wilson
Affiliation: Northwestern University
Address: ME Dept., 2145 Sheridan Rd., Evanston, IL 60201
Telephone: (312) 491-7099

Work is in progress to develop an experimentally validated model for the thick film hydrodynamic lubrication of axisymmetric stretch forming with a spherical punch. The work is intended as a basis for the development of improved lubrication systems, and frictional models for process simulation. The current model couples thermohydrodynamic lubrication theory with simple membrane plasticity theory. Experimental film thickness measurements using optical interferometry have shown that this model overestimates film thickness. Modifications to the theory to incorporate a better characterization of plasticity are in progress.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. ~~Other (Please Specify~~)
PLASTIC DEFORMATION

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
[✓ 7. Other (Please Specify)]
SQUEEZE & STRETCHING

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Lubrication in Metal Rolling

Name: William R. D. Wilson
Affiliation: Northwestern University
Address: ME Dept., 2145 Sheridan Rd., Evanston, IL 60201
Telephone: (312) 491-7099

Research over a number of years has dealt with the modelling of friction and lubrication in rolling of flat metal products. Experimentally validated models for the thick film regime which combine hydrodynamic, plasticity and thermal solutions to predict local film thickness, pressure and traction have been developed. Current research is centered on the mixed and boundary regimes including rough surface lubrication and plasticity of asperity flattening. Experiments are also in progress to understand the influence of non-newtonian lubricant behavior on film formation.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
[✓ 20. Other (Please Specify)] PLASTIC DEFORMATION

TYPE OF MOTION:

1. Sliding
2. Rolling
[✓ 3. Slide/Roll]
4. Impact
5. Reciprocating
6. Oscillating
[✓ 7. Other (Please Specify)]

SURFACE STRETCHING.

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Thermal Effects in Hydrodynamic Bearings

Name: William R. D. Wilson Affiliation: Northwestern University
Address: ME Dept., 2145 Sheridan Rd., Ecanston, IL 60201
Telephone: (312) 491-7099

An analytical study is aimed at understanding the interplay of the different modes of heat transfer in liquid lubricated bearings. The work is intended to provide a basis for understanding and a framework for comparing the results of various thermohydrodynamic numerical analyses of bearing performance.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Corrosion Wear in Rotary Engines

Name: R. Ted Wimber
Address: 3300 River Drive
Telephone: Moline, IL 61265

Affiliation: Deere & Company
Technical Center

Program will characterize corrosive environment in rotary engines and result in a test for evaluating candidate materials for rotor housing and apex seals.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED

- [✓ 1 Friction]
- [✓ 2 Wear]
- 3 Lubrication
- 4 Surface Damage
- 5 Failure
- 6 Fretting
- 7 Erosion
- 8 Adhesion
- [✓ 9 Abrasion]
- 10 Fatigue
- 11. Load Capacity
- 12. Surface Temperature
- 13 Contact Stress
- 14 Film Formation
- 15 Oil Analysis
- 16 Life
- 17 Filtration
- 18 Noise
- 19 Leakage
- 20 Other (Please Specify) CORROSION WEAR

TYPE OF MOTION

- [✓ 1. Sliding]
- 2. Rolling
- 3. Slide/Roll
- 4 Impact
- 5. Reciprocating
- 6. Oscillating
- 7. Other (Please Specify)

VARIABLES CONSIDERED

- [✓ 1. Load/Pressure]
- [✓ 2 Velocity]
- [✓ 3 Temperature]
- [✓ 4 Environment]
- [✓ 5 Dist/Time/Amp]
- [✓ 6 Geometry]
- [✓ 7. Finish/Lay]
- [✓ 8 Composition]
- [✓ 9 Structure]
- [✓ 10 Physical Properties]
- [✓ 11 Thermal Properties]
- [✓ 12 Chemical Properties]
- 13 Other (Please Specify)

LUBRICATION

- 1 Unlubricated
- [✓ 2 Liquid Lubrication]
- 3 Gas Lubrication
- 4 Grease Lubrication
- 5 Solid Lubrication
- 6 Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: R. J. WINDGASSEN
Affiliation: AMOCO OIL CO.
Address: BOX 400, NAPERVILLE, IL 60566
Telephone: (312) 420 [illegible] 4813

My work primarily involves formulation of products, using additives available from suppliers, trying to find combinations that will give the best overall match for the desired performance specifications.

At this point I can state that I came into lubricants six years ago after 25 years experience in other fields. My experiences with ASTM and other groups is that most industrial lubricant R+D is like my own, incremental and drawing on advances made 20 years ago.

In short, I don't really do research, but would like to be kept informed of your findings.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
[✓ 2. Rolling]
3. Slide/Roll
4. Impact
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Cavitation Erosion Research

Name: Dr. W.Z. Ben Wu
Affiliation: University of Missouri-Rolla
Address: Dept. of Engineering Mechanics
Telephone: University of Missouri, Rolla, Missouri, 65401
(314) 341-4313

The problems of cavitation erosion in fluid systems are pervasive. Because of the need to determine which materials are the best to use in these circumstances, at the present time committee G2, Erosion and Wear, of ASTM has set up a cavitation test task group to pursue this matter. The state-of-the-art paper survey in the related field has been done extensively. A vacuum nozzle for enhancing the cavitation erosion of a high pressure waterjet has been developed and analyzed. The standard ASTM vibration horn and the Lichtarowicz cell test method are being proposed for a series of inter-laboratory tests (a round robin). The fundamental investigation on the cavitation erosion mechanism is being carried out. The basic knowledge obtained could be applied to enhance the waterjet cutting and cleaning technology or to the protection of cavitation damage for metallic, ceramic, and composite materials.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
[✓ 7. Erosion]
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
[✓ 4. Impact]
5. Reciprocating
[✓ 6. Oscillating]
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Mark P. Wolverton
Affiliation: LNP Engineering Plastics
Address: 412 King Street, Malvern, PA 19355
Telephone: 215-644-5200

I am conducting an ongoing program investigating the friction, wear and LPV properties of thermoplastic composites. The primary test method is the thrust washer using steel, plastic composite, and other metallic counterfaces. The full journal bearing test is used for LPV data. Data are collected at 40 psi and 50 fpm at temperatures up to 500°F. A copy of our current, published data is enclosed.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
3. Lubrication
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
[✓ 6. Other (Please Specify)]
Self Lubrication

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE:

Name: Roger N. Wright
Affiliation: Rensselaer Polytechnic Institute
Address: Materials Engineering Dept., Materials Research Center, Troy, NY 12180-3590
Telephone: (518)266-6373

A research program entitled "Tool-workpiece Interactions Under Sheet Forming Conditions" is currently underway. It involves the development and testing of a die friction simulator. The simulator is being used to study pressure-friction-lubricant-surface quality interactions in drawing quality steels and coated steels. Tooling surface quality effects will be evaluated as well. This work is sponsored by General Motors.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED

[✓ 1 Friction]
2. Wear
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5 Failure
6 Fretting
7 Erosion
8 Adhesion
9 Abrasion
10 Fatigue
11. Load Capacity
12. Surface Temperature
[✓ 13. Contact Stress]
14 Film Formation
15 Oil Analysis
16. Life
17. Filtration
18 Noise
19 Leakage
20 Other (Please Specify)

TYPE OF MOTION

[✓ 1 Sliding]
2 Rolling
3. Slide/Roll
4 Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
3 Temperature
4 Environment
5 Dist/Time/Amp
[✓ 6. Geometry]
[✓ 7 Finish/Lay]
8 Composition
9 Structure
10 Physical Properties
11 Thermal Properties
12 Chemical Properties
13 Other (Please Specify)

LUBRICATION

[✓ 1 Unlubricated]
[✓ 2 Liquid Lubrication]
3 Gas Lubrication
4 Grease Lubrication
5 Solid Lubrication
6 Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: "A Study of Lubricant Rheology at High Pressures, Temperatures and Shear Rates"

Name: C. S. Peter Wu
Address:
Telephone:

Affiliation: Tribology Research Program in the Dept. of Chemical Engineering at The Pennsylvania State University

Principal Investigators: E. E. Klaus and J. L. Duda

A high-shear capillary viscometer and associated data analysis procedures have been developed to measure the non-Newtonian behavior of polymer-containing lubricants at elevated temperatures and shear rates. This experimental technique is now being used to explore the combined effects of high pressure, temperature, and shear rate on viscosity behavior of VI improved lubricants. By combining data obtained over a range of temperature, polymer concentration, and base oil viscosity, the viscosity of polymer solutions at the high temperatures, pressures and shear rates realized in bearings can be predicted.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
[✓ 7. Other (Please Specify)] Capillary Flow

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: "Formation of Lubricating Films by Vapor Deposition at Elevated Temperatures"

Name: Christopher Hsu
Address: Fenske Laboratory, Univ. Pk.
Telephone: (814) 865-2574

Affiliation: Tribology Research Program in the Dept. of Chemical Engineering at The Pennsylvania State University

Principal Investigators: E. E. Klaus and J. L. Duda

This project involves the study of the formation of lubricating films at elevated temperatures (up to 1000°C) by vapor deposition on a hot surface. The objectives are to determine the properties of the film and the mechanisms which control film formation.

Results show that the rate of film formation is very sensitive to the composition of the substrate material in addition to the influence of temperature, lubricant concentration, and the chemistry of the lubricant vapor. Several surface analysis techniques are being used to determine the composition of the films and various lubricants are being tested in order to determine the relationship between lubricant chemistry and film composition.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
[✓ 2. Liquid Lubrication]
[✓ 3. Gas Lubrication]
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: "Influence of Additive Molecular Structure on Lubricant Oxidation"

Name: Joe Hutter
Address: Fenske Lab, Univ. Park, PA
Telephone: (814) 865-2574

Affiliation: Tribology Research Program in the Dept. of Chemical Engineering at The Pennsylvania State University

Principal Investigators: E. E. Klaus and J. L. Duda

The Penn State microoxidation test is being used to study the influence of additive molecular structure on the oxidation of engine lubricants and industrial lubricants. The influence of additive structure on the rate of primary oxidation, the formation of high molecular weight oxidative products, evaporation, and deposits is being investigated.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
3. Lubrication
4. Surface Damage
[✓ 5. Failure]
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
[✓ 7. Other (Please Specify)]
Thin Film

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: "Low-Temperature Oxidative Behavior of Lubricants"

Name: Tim Dincher
Address: Fenske Lab., Univ. Park, PA
Telephone: (814) 865-2574

Affiliation: Tribology Research Program in the Dept. of Chemical Engineering at The Pennsylvania State University

Principal Investigators: E. E. Klaus and J. L. Duda

The goal of this project is to evaluate the oxidative and thermal stability of lubricants with various contaminants found in a typical internal combustion engine, and compare the results with engine tests that simulate city driving. The ultimate objective is to find a correlation between engine tests and a laboratory oxidation test which is based on a modification of the Penn State microoxidation test. A pressurized version of the Penn State microoxidation reactor is being used to evaluate the oxidative behavior of various lubricants in contact with water, soluble metals, and oxidized gasoline blow-by products.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
[✓ 12. Surface Temperature]
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
[✓ 7. Other (Please Specify)]
thin film

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
[✓ 3. Temperature]
[✓ 4. Environment]
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
[✓ 11. Thermal Properties]
[✓ 12. Chemical Properties]
13. Other (Please Specify)

LUBRICATION

1. Unlubricated
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
5. Solid

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: "A Study of for Formulation and Complex Rheology of Greases and Grease-Based Sealants"

Name: V. Zarkalis
Address: Fenske Lab., Univ. Park, PA
Telephone: (814) 865-2574

Affiliation Tribology Research Program in
the Dept. of Chemical Engineering at
The Pennsylvania State University

Principal Investigators: E. E. Klaus and J. L. Dud.

The complex rheology of greases and sealants is measured using a mechanical spectrometer (sophisticated common plate viscometer) and a mini rotor viscometer (a coaxial cylinder viscometer). The study of commercial greases and greases modified by different formulations and fillers indicates that the viscosity-shear rate behavior can be represented by a power law model. Furthermore, there are clear indications of thixotropic behavior and hysteresis phenomena. Techniques have been developed so that conventional greases can be modified by changing the structure of the grease and by incorporating fillers such as polyethylene, polyisobutylene, silica, etc.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
[✓ 6. Geometry]
7. Finish/Lay
8. Composition
9. Structure
[✓ 10. Physical Properties]
[✓ 11. Thermal Properties]
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
[✓ 4. Grease Lubrication]
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Contact Stress Analysis of Polymeric Subsurfaces for Wear Applications

Name: Jae R. Youn
Affiliation: University of South Carolina
Address: Dept. of Mechanical Engineering; Columbia, SC 29208
Telephone: (803) 777-7147

Polymeric subsurfaces are modelled as three different materials depending upon the mechanical properties; (1) homogeneous material , (2) homogeneous material with a soft surface layer, and (3) homogeneous material with a hard surface layer. The first material represents ordinary thermoplastics and thermosetts and gamma-irradiated polymers. The second material represents highly linear polymers whose surface layers are weaker than the bulk. The third material represents low temperature gas plasma treated thermoplastics with a thin crosslinked surface layer. A finite element method is employed to investigate the stress and stain distributions in the subsurfaces under normal and tangential loading. Elastic and elastic-plastic analyses have been accomplished successfully to identify the maximum shear stress and strain region. Especially the equivalent strain distribution obtained by the elastic-plastic analysis can tell the possible failure region in the subsurface. The different wear behavior of polymers, e.g., thin film or thick wear debris transfer, can be explained by the stress and strain distribution.

Contact stress distribution in an elastic-plastic subsurface under cyclic loading will be investigated in the future. The wear film formation due to failure will be illustrated by the investigation. Wear mechanism of fiber composite materials will also be investigated by analyzing stress distribution in the matrix and the fibers under applied traction. The fiber fracture processes will be studied to explain the effect of fiber orientation on fiber damage in the composites during sliding wear.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1 Friction]
[✓ 2 Wear]
3 Lubrication
[✓ 4 Surface Damage]
5 Failure
6 Fretting
7 Erosion
8 Adhesion
9 Abrasion
10 Fatigue
11 Load Capacity
12 Surface Temperature
[✓ 13 Contact Stress]
14 Film Formation
15 Oil Analysis
16 Life
17 Filtration
18 Noise
19 Leakage
20 Other (Please Specify)

TYPE OF MOTION:

[✓ 1 Sliding]
2 Rolling
3 Slide/Roll
4 Impact
5 Reciprocating
6 Oscillating
7 Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1 Load/Pressure]
[✓ 2 Velocity]
3 Temperature
4 Environment
5 Dist/Time/Amp
6 Geometry
7 Finish/Lay
[✓ 8 Composition]
9 Structure
[✓ 10 Physical Properties]
11 Thermal Properties
12 Chemical Properties
13 Other (Please Specify)

LUBRICATION:

[✓ 1 Unlubricated]
2 Liquid Lubrication
3 Gas Lubrication
4 Grease Lubrication
[✓ 5 Solid Lubrication]
6 Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Recycling of Metalworking Fluids in Manufacturing

Name: Laurie Zelnio
Address: 1100-13th Avenue
Telephone: 309/7[redacted]52-6272

Affiliation: John Deere Harvester - Materials Engineering Dept

PROJECT TITLE: Reduction of Lubricant Types used in the Manufacturing Environment

PROJECT TITLE: Extending the Life of Factory Hydraulic Lubricant

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

1. Friction
2. Wear
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
8. Adhesion
9. Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
[✓ 15. Oil Analysis]
[✓ 16. Life]
[✓ 17. Filtration]
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

1. Sliding
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

1. Load/Pressure
2. Velocity
3. Temperature
4. Environment
5. Dist/Time/Amp
6. Geometry
7. Finish/Lay
8. Composition
9. Structure
10. Physical Properties
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

1. Unlubricated
2. Liquid Lubrication
3. Gas Lubrication
4. Grease Lubrication
5. Solid Lubrication
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: In-situ Solid Lubrication via Surface Segregation

Name: Zwy Eliezer
Address: Dept. of Mechanical Eng.
Telephone: The Univ. of Texas at Austin
Austin, TX 78712
(512) 471-3186

Affiliation: The Department of Mechanical Engineering and The Center for Materials Science and Engineering,
The University of Texas at Austin

Preliminary work performed in our laboratories unequivocally demonstrated the possibility of using surface segregation as a vehicle for the formation of an in-situ, inexhaustable solid film lubricant.

Current work is aimed at extending the range of speed, load, and environmental conditions under which such a beneficial effect can be obtained. This stage of the project is concerned with the evaluation of certain elements in groups IV, V, and VI of the periodic table which, because of their tendency to reduce grain boundary cohesive energy, may promote solid lubrication by segregating to the surface during sliding.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
4. Surface Damage
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
9 Abrasion
10. Fatigue
11. Load Capacity
12. Surface Temperature
13. Contact Stress
14. Film Formation
15. Oil Analysis
16. Life
17. Filtration
18 Noise
19 Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
4. Environment
[✓ 5 Dist/Time/Amp]
6. Geometry
7 Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13 Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
2. Liquid Lubrication
3 Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Wear of Metallic Coatings

Name: A.W. Ruff
Affiliation: National Bureau of Standards
Address: B266/Materials Bldg., Gaithersburg, MD 20899
Telephone: (301) 975-6010

This project involves basic research into the properties of metallic coatings that determine their sliding wear performance. Typical coatings range from electron beam surface melted layers on iron alloys and on copper alloys, to electrodeposited alloy coatings on steel substrates. Sliding wear tests are conducted under different conditions of load, speed, and contact geometry; tests are done both unlubricated and lubricated. Self-mated tests and tests of the coatings sliding against bearing steels are done. Data recovered during the test period include instantaneous friction, wear (from displacement gauges), and temperature. Post test examination utilizes optical and electron metallography methods, to determine coating adherence to the substrate, and the nature of damage during wear. X-ray emission analysis in the SEM determines the composition of solid, built-up films. Surface profiling is used to measure the wear volume. Results are correlated with coating structure and composition.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
[✓ 10. Fatigue]
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
6. Geometry
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

DESCRIPTION AND CLASSIFICATION OF SPECIFIC BASIC/APPLIED RESEARCH

Please type all information and provide a brief summary of project goals, methods of approach, recent findings and future directions.

PROJECT TITLE: Wear Test Methods and Standards

Name: A.W. Ruff
Affiliation: National Bureau of Standards
Address: B266/Materials Bldg., Gaithersburg, MD 20899
Telephone: (301) 975-6010

This project develops improved measurement and test methods for friction and wear studies. Where appropriate, standard methods are developed, including standard reference materials. The aim of the work is to improve the reproducibility of existing test methods, or if necessary to develop new methods for conducting laboratory, bench-type tests. All of the standards work is done jointly with U.S. or international groups, where many other laboratories are involved and have significant roles in the process. It is desirable that the wear tests are simple in configuration and in specimen requirements, and that the test systems are well characterized in mechanical response. Within-laboratory and between-laboratory comparisons are used to assess the basic reproducibility of the test method. Since its inception the project has contributed significantly to the development of 4 U.S. standards, 1 reference material, and 1 international standard.

(Please Circle All Appropriate Parameters)

PROCESS OR PHENOMENON BEING STUDIED:

[✓ 1. Friction]
[✓ 2. Wear]
[✓ 3. Lubrication]
[✓ 4. Surface Damage]
5. Failure
6. Fretting
7. Erosion
[✓ 8. Adhesion]
[✓ 9. Abrasion]
10. Fatigue
[✓ 11. Load Capacity]
[✓ 12. Surface Temperature]
[✓ 13. Contact Stress]
[✓ 14. Film Formation]
15. Oil Analysis
16. Life
17. Filtration
18. Noise
19. Leakage
20. Other (Please Specify)

TYPE OF MOTION:

[✓ 1. Sliding]
2. Rolling
3. Slide/Roll
4. Impact
5. Reciprocating
6. Oscillating
7. Other (Please Specify)

VARIABLES CONSIDERED:

[✓ 1. Load/Pressure]
[✓ 2. Velocity]
[✓ 3. Temperature]
[✓ 4. Environment]
[✓ 5. Dist/Time/Amp]
[✓ 6. Geometry]
7. Finish/Lay
[✓ 8. Composition]
[✓ 9. Structure]
[✓ 10. Physical Properties]
11. Thermal Properties
12. Chemical Properties
13. Other (Please Specify)

LUBRICATION:

[✓ 1. Unlubricated]
[✓ 2. Liquid Lubrication]
3. Gas Lubrication
4. Grease Lubrication
[✓ 5. Solid Lubrication]
6. Other (Please Specify)

NIST-114A
(REV. 3-89)

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY

BIBLIOGRAPHIC DATA SHEET

1. PUBLICATION OR REPORT NUMBER
NISTIR 89-4112

2. PERFORMING ORGANIZATION REPORT NUMBER

3. PUBLICATION DATE
July 1989

TITLE AND SUBTITLE

The Development and Use of a Tribology Research-in-Progress Database

AUTHOR(S)

S. Jahanmir and M. B. Peterson

PERFORMING ORGANIZATION (IF JOINT OR OTHER THAN NIST, SEE INSTRUCTIONS)

U.S. DEPARTMENT OF COMMERCE
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
GAITHERSBURG, MD 20899

7. CONTRACT/GRANT NUMBER

8. TYPE OF REPORT AND PERIOD COVERED

SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (STREET, CITY, STATE, ZIP)

10. SUPPLEMENTARY NOTES

☐ DOCUMENT DESCRIBES A COMPUTER PROGRAM; SF-185, FIPS SOFTWARE SUMMARY, IS ATTACHED.

11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.)

Preliminary efforts leading to the development of a research-in-progress database on tribology are described. The database contains brief abstracts of current tribology research being conducted by industry, universities, research institutes and government laboratories based on a survey of active researchers. It also contains information on the types of activities, general areas of interest, program objectives, and tribology applications. The database can be used to evaluate the current status of research and development activities in the United States. The survey results suggest that there is a strong interest in an applied research in tribology, and that the level of basic fundamental research is extremely limited. The primary program objectives cited in connection with the tribology activities include long life, low maintenance, failure-free machinery, fundamental understanding, and materials development for improved performance. It is planned to expand and update the database on a regular basis.

12. KEY WORDS (6 TO 12 ENTRIES; ALPHABETICAL ORDER; CAPITALIZE ONLY PROPER NAMES; AND SEPARATE KEY WORDS BY SEMICOLONS)

applied research; basic research; bearing, computerized information; database; gear; lubrication; technology transfer; tribology

13. AVAILABILITY

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14. NUMBER OF PRINTED PAGES
314

15. PRICE
$32.95

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AMERICAN BINDERY
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5-94